STATE OF RHODE ISLAND

STORM WATER DESIGN AND INSTALLATION STANDARDS MANUAL

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The principal author of this manual is James Boyd, formerly a Water Quality Specialist with the Division of Water Resources, Rhode Island Department of Environmental Management (RIDEM). currently an Environmental Scientist with the Rhode Island Coastal Resources Management Council (RICRMC). This manual is the result of a collaborative effort between the RIDEM and the RICRMC. The author is indebted to many individuals for their contributions, input, and review of this document, particularly Elizabeth Scott who provided the opportunity to work on the manual. The following people have been especially gracious with their time and effort: Lynn Carlson, Dean Albro, the late Henry Sardelli, Brian Tefft, Susan Adamowicz, and Jed Merrow from the RIDEM and Tom Medeiros, Nick Pisani, Ken Anderson, and Dave Reis from the RICRMC. Additionally, the information and comments provided by Carol McGinness, Sarth Porter, and Vincent Palumbo from the Department of Transportation and by private engineering consultants Steve Cabral, Russell Ferland and Edward Spinard were most helpful in organizing the manual. I thank everyone for their support and hope that this manual will be helpful in addressing stormwater generated nonpoint source pollution in Rhode Island.

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SECTION 1

INTRODUCTION

Rhode Island's regulatory agencies are acutely aware of the deleterious effects of uncontrolled and untreated stormwater discharges to surface and ground waters. Stormwater runoff is responsible for transporting eroded sediments, nutrients, petroleum hydrocarbons, heavy metals[1] pesticides, road salts, pathogenic bacteria, and viruses as well as other pollutants to receiving waters. The Nationwide Urban Runoff Program studies (USEPA, 1983) and the Rhode Island §305(b) and §319 reports have documented the detrimental water quality impacts associated with these nonpoint source pollutants from untreated stormwater runoff. In addition, Section 6217 of the 1990 Coastal Zone Act Reauthorization Amendments (CZARA) requires each coastal state, with federally approved coastal zone management programs, to develop a non-point source pollution control program. One of the main focuses of the Section 6217 requirements is proper stormwater management. The stormwater design, performance, installation, and maintenance standards contained within this manual are consistent with these federal requirements.

For the purposes of this manual, 'stormwater management is defined as: 'a system of vegetative, structural, and/or other measures that controls the volume and rate of stormwater runoff and minimizes flooding and water quality degradation which can result from land disturbing activities.' The main emphasis of stormwater management is the reduction of impervious surfaces in all types of developments and the use of proven techniques to control peak discharge rates, reduce runoff volumes, and improve water quality leaving the site.

<u>Who should use this manual</u>?

This manual has been prepared to assist property owners, developers, engineers, consultants, contractors, municipal planners and others in planning and designing effective stormwater best management practices. The material contained within the manual is provided as guidance to those persons involved in the development of properties, many of which will be subject to state and local regulatory permit requirements. This manual should be used by applicants to:

- Coastal Resources Management Council (CRMC);
- Department of Environmental Management (DEM); and,
- Local municipalities that have stormwater ordinances.

Municipal officials, including planners and engineers, can use the manual to support local stormwater management programs. This may include incorporating or referencing the manual into local ordinances.

<u>How does this manual relate to existing state regulations?</u>

The DEM currently administers a number of programs that require stormwater management. Depending on site conditions and how stormwater is managed, different regulations apply. The CRMC also has stormwater management requirements that apply to projects located within that agency's jurisdiction. This manual should be used by applicants to the DEM and CRMC. Applicants are encouraged to adhere to the recommended design and performance criteria in this manual. Where an applicant deviates from the design standards, a technical justification may be required by the permitting entity. Use of the manual does not relieve an applicant from complying with other applicable regulatory requirements. As mentioned above, certain criteria outlined in this manual may be made mandatory via amendments to existing regulations.

<u>What is a stormwater management plan</u>?

A stormwater management plan is a description of proposed best management practices, detailed site plans, and a written narrative, that, when implemented, provides protection and restoration of receiving waters by reducing pollutant loadings and other negative impacts associated with changes in land use (i.e., urbanization). In addition, a stormwater management plan assists in protecting natural resources such as drinking water reservoirs, wetlands and other important freshwater and marine ecosystems. Effective stormwater management planning is accomplished during the initial design phase of the project through careful analysis of the proposed change in land use for the site. By reducing the surface area of roadways, parking lots, and roof tops, the volume of stormwater runoff generated will be reduced. This will result in less pollutants being transported from the development site to Rhode Island's waters. The size and extent of required BMPs can be minimized by reducing the area of impervious surfaces and the volume of stormwater runoff.

Best management practices (BMPs) are described as structural devices that temporarily detain and treat stormwater runoff in order to control peak discharge rates and reduce pollutant loadings. The mechanisms for pollutant removal are based on gravity settling, infiltration, and biological uptake. Typical BMPs include wet ponds, infiltration trenches, created wetlands, grassed swales, etc.

The following elements are necessary for stormwater management plans when required by CRMC, DEM, or local municipalities. The applicant must provide:

1. A plan that identifies all best management practices for the proposed development. These
EMPs must be illustrated on detailed site plans and described within the written plan. See Section 13 of this manual for recommended site plan requirements.

2. A maintenance schedule for each best management practice as detailed in Section 12 of this
manual.

3. A written narrative that describes the proposed measures to reduce peak discharge rates, maintain sheet flow of stormwater runoff (where possible) and improve water quality. Additionally, the applicant should demonstrate that impervious surfaces have been reduced to the greatest extent possible and that site disturbance will be the minimum necessary for the proposed project while maintaining as much natural undisturbed vegetation on-site as possible.

The following steps should be observed in order to detennine the **appropriate** size and design of structural storniwater BMPs:

1. Determine whether the proposed project must control peak discharge rates from stormwater runoff as defmed in Section 2, herein. This determination will define the size and extent of required BMPs.

2. Calculate the required water quality volume as detailed in Section 2 of this manual.

3. Calculate the additional volume required for long term (10 year recommended) storage of accumulated sediments as detailed in Section 3, herein. Most BMPs should also incorporate a pretreatment device as described in Section 7, herein.

4. Design the liMPs according to the standards contained in the applicable design sections within this manual.

It cannot be emphasized enough to engineers and planners that minimizing site disturbance and conserving vegetated buffers will reduce development generated impacts to receiving waters. Buffers can be incorporated extremely well into the landscape features of a new development, while enhancing the aesthetic qualities and marketability of the site.

Another important aspect of improving water quality on-site is the reduction of pollution sources. Pollutant reduction measures may be critical in developments adjacent to sensitive resource areas (e.g., drinking water reservoirs, coastal salt ponds, etc.). For example, road deicing agents (salt) are not removed via storrnwater detention basins or infiltration methods, therefore road salt applications should be reduced. Similarly, the use of pesticides and fertilizers applied to maintained lawn areas should be greatly reduced or avoided all together. The reduction of potential pollution sources must be a priority for developments in sensitive areas to achieve resource protection goals.

How to use this manual

During the project design phase applicants should reduce the area of impervious surfaces and minimize, to the greatest extent possible, site disturbances. The design engineer must investigate the most effective best management practices for the proposed development. Physical features present on the site may limit the type or design of proposed liMPs, and thus are an extremely important consideration during the selection process. Examples of site constraints that may influence BMP selection are steep slopes, shallow depth **to** bedrock, shallow groundwater elevations, or extensive wetlands located on-site. The best management practices proposed for the development should also be incorporated into the landscape plan. BMPs should become amenities for the development site which add open space, wildlife habitat, recreational areas, and screening between different land uses, while also providing peak discharge rate control and pollutant reductions resulting from stormwater runoff. Many residential areas located adjacent to large stormwater wet ponds have been marketed as “waterfront properties”, and command higher real estate values.

Applicants are encouraged to utilize the following publications to assist in designing appropriate best management practices for the proposed development: the latest edition of the Rhode Island Soil Erosion and Sediment Control Handbook (available from Soil Conservation Service, DEM Office of Environmental Coordination, or RI Resource Conservation and Development Office); Controlling Urban Runoff; A Practicable Manual for Planning and Desiening BMP's (Schueler, 1987); and, A Current Assessment of Urban Best Management Practices . Techniaues for Reducing Mon-point Source Pollution in the Coastal Zone (Schueler, Kumble, and Heraty, 1992).

To ensure that the project meets the state's regulatory requirements, applicants should consult **DEM** freshwater wetlands, water quality, Rhode Island Pollutant Discharge Elimination System **(RJPDES),** and under ground injection control regulations. Applicants should also consult the Rhode Island Coastal Resources Management Program and applicable special area management plans (e.g., Rhode Island's Salt Pond Region: A Special Area Management Plan and The Narrow River Special Area Management Plan) **if** the project is located within CRMC jurisdiction. In addition, applicants should consult with their local building official in order to identify any local stormwater management or erosion and sediment control ordinances.

For further information contact:

Rhode Island Department of Environmental Management	
Division of Freshwater Wetlands	277-6820
Division of Water Resources	277-3961
Water Quality Certification Program	
RIPDES Program	
Division of Groundwater	277-3162
Underground Injection Control Program	
291 Promenade Street	
Providence, RI 02908	

Coastal Resources Management Council	277-2476
Oliver Stedman Government Center	
Tower Hill Road	
Wakefield, RI 02879	

NOTE: Stormwater regulations to cover "stormwater associated with industrial activities" will be added to the existing RJPDES regulations.

SECTION 2

STORMWATER MANAGEMENT PERFORMANCE STANDARDS

Water Quantity

Water quantity control is an important component in effective stormwater management planning. Controlling runoff volumes and peak discharge rates alleviates localized flooding and erosion problems. However, the cumulative effects of even moderate development within a watershed may significantly increase flood elevations downstream due to the altered timing of stormwater discharges. Therefore, a regional approach to stormwater management may be desirable for watersheds experiencing regular flooding problems. **Applicants** are advised to maintain postdevelopment peak runoff rates and average volumes at predevelopment levels to the greatest extent practicable.

The following requirements apply to programs that have regulatory stormwater standards. Please note **that** the 24-hour, Type III distribution storm event must be analyzed when using Soil Conservation Service methods.

1. Proposed projects must control and maintain postdevelopment peak discharge rates from the
2-year and 25-year storm events at predevelopment levels.

2. Downstream analysis of the 100-year storm event shall be required. When deemed necessary, control of the peak discharge rate for the **100-year** storm shall be required to mitigate significant downstream impacts.

Requirements I and 2 may be waived where;

(a) the applicant has obtained local or state approval to discharge stormwater runoff to an existing storm drain system without increased erosion at the outlet or,

(b) the stormwater runoff is conveyed non-erosively to tidal waters. However, the applicant must comply **with** Section 300.6 of **the** Coastal Resources Management Program.

3. The discharge from any stormwater facility must be conveyed through properly constructed water courses to provide for non-erosive flows during all storm events. The proposed stormwater conveyance system consisting of open channels, pipes, etc. shall at minimum accommodate the runoff from a 10-year storm event or a greater event if required by other local, state, or ***federal*** regulations. These stormwater conveyance systems must provide for non-erosive flows to receiving waters.

4. All stormwater detention basins must be constructed to safely withstand or pass **through** the discharge from the 100-yr runoff flows from the contributing drainage area.

Specifically, detention basins shall be constructed to 'withstand' the tOO-yr runoff flows and must be capable of controlling these flows without failure or damage to the basin and/or detaining berms. Certification by the design engineer as to meeting this requirement shall be provided on the design plans for the proposal. The applicant is advised to meet the DEM Division of Freshwater Wetlands Dam Safety Standards for detention basins that incorporate berms or dams into the design. Annual inspections may be necessary to insure structural integrity and maintain public safety standards. These inspections should be included in the maintenance plans submitted for review.

5. The applicant must demonstrate that the proposed design provides the necessary controls by submitting predevelopment and postdevelopment composite hydrographs reflecting existing and proposed conditions. The permitting entity will make the final determination with respect to control of runoff water generated by proposed projects on a case-by-case basis. Additionally, an exemption for control of peak discharge rates <u>does not</u> exclude applicants from meeting water quality requirements as specified below.

The most widely used method for determining runoff volumes, peak discharge rates, and storage requirements is the Soil Conservation Service's (1986) revised Technical Release ***55*** (TR-55). This is the preferred method for projects area with approximate areas of between one and 2000 acres. TR-55 is a popular computer-based model that account-s for antecedent soil moisture, hydrologic soil group, vegetative cover type, and land management practices in the evaluation of runoff characteristics. Another SCS method that may be more suitable for some analyses (e.g., multiple watershed projects) is the Technical Release 20 (TR-20) program (SCS, 1983).

The Rational Method (ASCE, 1960) is the preferred technique for pavement drainage calculations needed **to** size **drainage components in highway, industrial, and commercial applications. Other methods may be used for calculating runoff** peak **discharge rates** and **volumes, provided the applicant submits all of the** necessary **information for the review process. The models along with all assumptions** and **relevant data must be clearly documented and** are **subject to permitting agency approval.**

<u>Water Qualitv</u>

Over the past decade numerous studies have documented the poor quality of storinwater runoff from urbanized areas. The largest effort was conducted **by** the Environmental Protection Agency, which characterized the most common pollutants found in urban runoff **(USEPA, 1983).** Treating stormwater runoff with a variety of best management practices can achieve substantial reductions in pollutant loads and improve water quality in receiving waters.

The CRMC and DEM have established a minimum 80 percent removal rate, over an average annual basis, for total suspended solids (TSS) contained in stormwater runoff. This removal rate is based on criteria established by Section 621[7](g) of the Coastal Zone Act Reauthorization Amendments of 1990 which mandates that the State of Rhode Island adopt and implement this minimum standard for reducing non-point source pollution within the coastal zone.

The P8 program, a recently developed urban runoff model (Walker, 1990), was utilized to evaluate the efficiency of stormwater runoff control facilities in removing pollutant toads. These analyses have demonstrated that a volume calculated by multiplying one-inch by the impervious surface area contained within a contributing drainage area, and incorporated into a properly designed BMP, will result in a reduction of the average annual TSS loadings by 80 percent. This volume requirement is a design standard and must be applied as specified below.

The following design standards, based on the water quality volume defined above, are the minimum requirements to meet the 80 percent TSS removal rate performance standard.

1. Wet ponds must have a permanent pool volume equal to the water quality volume described above.

2. Extended detention dry ponds must detain the water quality volume over a 36-hour period (brim draw-down time).

3. Infiltration methods must be designed to retain and exfiltrate the water quality volume over a maximum 72-hour period.

The 80 percent TSS removal standard is based on the above noted design standards and as specified in Sections 4 through Ii, herein. Where site conditions restrict the construction of BMPs that will not meet these design criteria, then the applicant must provide within the Narrative Description (as describe in Section 13) how the 80 percent TSS removal rate will be obtained.

Additional volumes must be incorporated into the BMP designs to store expected sediment loads from the contributing drainage area. A 10-year sediment storage volume is recommended, although more frequent sediment removal in some cases can obviate the need for the 10-year volume. The additional sediment storage volume should be consistent with the specific individual BMP maintenance schedule. Often, this sediment storage volume can be designed in accordance with a properly sized pretreatment device (refer to Sections 3 and 7, herein).

Stormwater discharges to drinking water reservoirs and their tributaries, degraded water bodies, poorly flushed estuaries, and Outstanding Natural Resource Waters (ONRWs) may require higher pollutant removal efficiencies (i.e., greater than 80%) to meet RI anti-degradation policies and RI Water Quality Regulations for Water Pollution Control. Where required by the permitting agency, the applicant must submit a detailed report of the potential detrimental effects from the project on the receiving water. An analysis of predevetopment versus postdevelopment pollutant loading rates and all supporting data must be included in this report. The applicant may be required to construct best management practices that achieve higher pollutant removal rates and mitigate potential detrimental effects to satisfy water quality goals. These methods could include the use of best management practices in series (Wengrzynek and Terrel, 1990). For example, runoff could flow into a wet pond, then through a vegetated swale connected to an artificially created wetland. In this manner, better water quality is achieved to reduce or eliminate impacts to pollution sensitive waters.

The amount of impervious surfaces associated with the project will determine the size and scope of required best management practice(s) to achieve peak discharge rate control and pollutant load reductions from the site. The design standards will result in the appropriate scaling of these BMPs to meet the established TSS removal rate. Relatively small sites might find the addition of a simple grass swale or vegetated filter strip sufficient to mitigate the effects of pollutants from small parking facilities. Alternatively, larger facilities (i.e., shopping malls, industrial complexes. etc.) may have to construct more complex stormwater management systems (e.g., wet ponds, vegetated swales, and artificially created wetlands utilized in series) to handle the proportionally larger volumes of runoff water and associated pollutant loads.

Industrial sites are included under the new USEPA National Pollution Discharge Elimination System (NPDES) stormwater discharge requirements contained in Title 40 of the Codified Federal Register, due to potentially hazardous materials associated with many industrial activities. A RIPDES permit may be required for many industrial sites and is available through the DEM Division of Water Resources. Please see Appendix A for a definition of "stormwater discharges associated with industrial activity".

The P8 program may be used as a regulatory tool to determine if proposed water quality BMPs are meeting the required 80 percent TSS removal rate. Several PS work sheets are provided in Appendix B of this manual for the convenience of applicants. The applicant is encouraged to complete and submit these worksheets with all other information to the permitting agency for review. Other methods may also be utilized for calculating pollutant removal rates or loadings.

SECTION 3

CALCULATING SEDIMENT ACCUMULATION VOLUMES

3. I Introduction

An important component in planning the capacity of stormwater control facilities is the additional volume necessary to accommodate the expected sediment loads *from* developed areas. Winter road and parking lot de-icing operations and annual particle deposition can result in significant volumes of sediments being transported through the drainage system. The accumulated sediment volumes must be accounted for when calculating the volume requirements of stormwater control facilities. A ten year clean-out cycle is recommended for sediment removal, however with a proper maintenance plan alternative clean-out cycles may be acceptable. The sediment accumulation volume for the cycle should be added to the water quality design standard.

The recommended 10 year clean out cycle for sediment removal is reasonable for best management practices serving stabilized land uses. The costs can be spread out over the 10 year period, thus making the clean out procedures more affordable. During the first year of operation it may be necessary to remove accumulated sediments from best management practices more often, especially in areas where site stabilization practices were inadequate. Therefore, it is imperative that the contractor utilize proper soil erosion and sediment control methods during site development to reduce the overall cost of BMP sediment removal. The latest edition of the Rhode Island Soil Erosion and Sediment Control Handbook will greatly assist in this process. Routine inspections of drainage networks and detention ponds may be required after site stabilization to ensure proper functioning of the stormwater system. Sediments accumulated within basins prior to site stabilization may have to be removed to the satisfaction of the permitting agency.

3.2 Methods

The following equations were developed by the DEM Stormwater Management and Erosion Control Committee for calculating sediment accumulation volumes (DEM, 1988). To calculate sediment loss from unstablized areas, especially new construction sites, the applicant should use the method outlined in Chapter 7 within the most recent version of the Rhode Island Soil Erosion and Sediment Control Handbook.

Equation #1: for low density residential development (lot size greater than 1/4 acre). SV = [(76.6 x RA x TE) + (4.0 x DA x TE)] x T

Equation #2: for high density residential development (lot size less than or equal to 1/4 acre, commercial or industrial land use.

SV = [(76.6 x RA x TED + (15.3 x DA x TE)) x T where, SV = sediment volume (ft')

RA = area of roadway and parking lots (acres)

TE = basin trap efficiency (80% standard)

DA = contributing land use area (acres)

T = time (years)

Example: A 50 acre development is planned with 40 acres reserved for I acre house lots with a commercial shopping plaza planned for the remaining 10 acres. Assume the residential development will have 20% impervious area resulting in 8 acres of roads, roof tops, and driveways, while the commercial plaza will have 60% impervious area resulting in 6 acres of parking lot, roads, and roof top. A wet pond is proposed to improve water quality and meet the stormwater requirements.

The calculation for the low density area is as follows:

$$SV = [(76.6 \text{ x } 8 \text{ x } 0.80) + (4.0 \text{ x } 40 \text{ ,c } 0.80) \text{ x } 10 = 6182 \text{ ft}^3$$

The calculation for the high density area is as follows:

$$SV = [(76.6 \text{ x } 6 \text{ x } 0.80) + (\boldsymbol{15.3} \text{ x } 10 \text{ x } 0.80) \text{ x } 10 = 4901 \text{ ft}^3$$

The sum of these two volumes is 6182 ft' + 4901 ft' = 11,083 ft'. Therefore, this total sediment accumulation volume should be added to the design standard volume for the proposed wet pond.

SECTION 4

WET PONDS

4.1 Introduction

Wet ponds can be extremely effective as water quality best management practices (**B**MPs), if properly sized and maintained. This type of BMP can also be designed to reduce peak discharge rates of stormwater runoff when the appropriate additional volume and outlet device are incorporated into the pond design. Wet ponds are essentially permanent pools of water that decrease the velocity of runoff as it enters the basin and allows settling of sediments and suspended matter. Gravity settling is the primary removal mechanism for particles and sediments in the permanent pool area. The removal rate of these particles is directly related to the physical attributes of the pond, including geometry, volume, depth, and detention time. Microorganisms and plants that reside in the pond and bottom sediments assist in biological uptake and degradation of many pollutants. The function of biological uptake is also important in reducing the levels of nutrients, especially phosphorus and nitrogen, in runoff prior to discharge to a receiving water.

The goal of the stormwater management plan is to control both peak discharge rates and improve r water quality. These objectives can be accomplished when a wet pond is combined with a detention basin to form a complete stormwater facility. Wet ponds can be valuable assets to the community by providing visual aesthetics, recreation, wildlife habitat, and increasing the value of nearby real estate. Oftentimes town houses or condominium are marketed as ‘water front properties” when located adjacent to wet pond stormwater facilities. Wet ponds should be incorporated into the natural landscape to enhance the functional values of the pond and provide visual amenities to the site.

Agriculture Handbook Number 590. Ponds: Planning. Design. Construction published by the Soil Conservation Service (1982) may be helpful when considering the application of wet ponds for a development site. Also, the guidelines in Earth Dams and Reservoirs. Technical Release Number 60 (1985) and the Standards and Specifications for Ponds (Number 378) also published by the Soil Conservation Service should be followed when designing and constructing impoundment (berm or dike) structures. Furthermore, the information supplied in Stormwater Basin Plants and Landscaping Guide; A Simple Guide for Designers and Communities by the Land Management Project (1991) will be helpful in creating aesthetically pleasing basins and improving pollutant removal capabilities.

4.2 Site Suitability

(a) The contributing area to the pond should be greater than **10** acres. This is the minimum area required by Soil Conservation Service methods to maintain a permanent pool during high evaporative conditions and a low frequency of rainfall events.

(b) The lowest elevation within the basin should be a minimum of 12 inches above the seasonal high water table elevation unless an impermeable geomembrane is utilized. This is necessary to reduce the potential for contaminants to pollute underlying groundwater.

(c) If wet basins are proposed for soils with the textural classes Sand, Loamy sand, Sandy loam, or Loam; then a 6 inch layer of compacted clean silt or clay should be added to the basin bottom and sides to reduce water seepage. This layer should be overlain by a 3 inch cover of sand or gravel to protect the liner and act as an indicator of excessive dredging during routine maintenance procedures. Impermeable geomembranes may also be used, providing the membrane is covered with the recommended cover of sand or gravel as specified by the manufacturer. All shallow portions of the basin bottom that are to be planted with wetland plants should have a 6 inch layer of organic soil as a final layer to promote plant growth.

(d) In soils with textures of Silt loam or finer the surface of the basin can be compacted by heavy machinery (e.g., rollers) to prevent seepage of basin water into the underlying groundwater.

(e) Ponds cannot be constructed in existing stream channels, wetlands or other waters of the State without approval by the permitting agency, nor should they receive permanent or continuous flow from any surface water body.

(C Ponds should not be located in areas that receive discharge from springs or subsurface groundwater flow.

(g) There should be a separation distance of at least 25 feet between the basin and the property boundary of the nearest lot. This separation distance creates a safety buffer between the basin and adjacent properties. This distance may be reduced with proper fencing or landscaping.

(h) Basins should not be located within 50 feet to any component of an individual sewage disposal system (subject to SD 3.00 of the DEM ISDS regulations).

(i) Basins cannot be constructed in utility right-of-ways (e.g., sewer or electric lines) without obtaining written authorization (easement).

4.3 Volume

(a) The minimum required permanent pool volume is determined by multiplying the total impervious surface areas of the contributing watershed by 1 inch. The volume required for the permanent pool can be reduced if roof top runoff is infiltrated on-site. This procedure allows roof tops to be subtracted from total impervious areas, thus reducing the total amount of runoff routed to the permanent pool. The major concern is with roads, driveways and parking lots where many runoff-borne pollutants originate. The practice of infiltrating roof top runoff assists in recreating the natural infiltration conditions of the site prior to development. In addition, it decreases the size and associated costs of construction and maintenance for the basin. Infiltration of roof top runoff should be restricted to residential buildings or other buildings that do not have air pollution, venting, cooling, or heating equipment located on the roof.

(b) It is necessary to incorporate additional volume to the wet pond to account for the accumulation of sediments from the contributing watershed. The recommended minimum additional volume is determined by calculating sediment accumulation over 10 years. See Section 3 for calculating sediment accumulation from the site.

(c) If a wet pond is a component of a detention basin, forming a combined flood control and water quality improvement facility, then the guidelines for detention basin designs provided in Chapter 6 of the most recent version of the Rhode Island Soil Erosion and Sediment Control Handbook (1989) must be followed. In addition, the guidelines in Earth Dams and Reservoirs. Technical Release Number 5Q published by the Soil Conservation Service (1985) may also be applicable.

4.4 Geometry

(a) A minimum length to width ratio of 3:1 is recommended for any basin. This provision maximizes the length of flow between the inlet and outlet points and contact within the basin to promote settling of suspended solids. If site constraints prohibit the construction of a long narrow pond, then diversion structures such as baffles, gabions, or islands should be incorporated into the pond design to increase the flow length and accomplish the objective of a long narrow pond (see Figure 4.!). Applicants must clearly demonstrate these site constraints. Be sure to account for reduction of pond volume due to these structures.

(b) Ponds should have a wedge-shaped design with the inlet at the narrow end of pond and the widest portion at the outlet. This shape promotes plug flow of incoming stormwater and increases the efficiency of pollutant removal within the pond.

(c) The outlet should be located at the opposite and farthest end of the pond from the inlet. This requirement prevents dead storage areas, short circuiting and inefficient treatment of runoff by maximizing the length of flow. To promote better settling of suspended particles and sediments there should only be a single inlet to the basin.

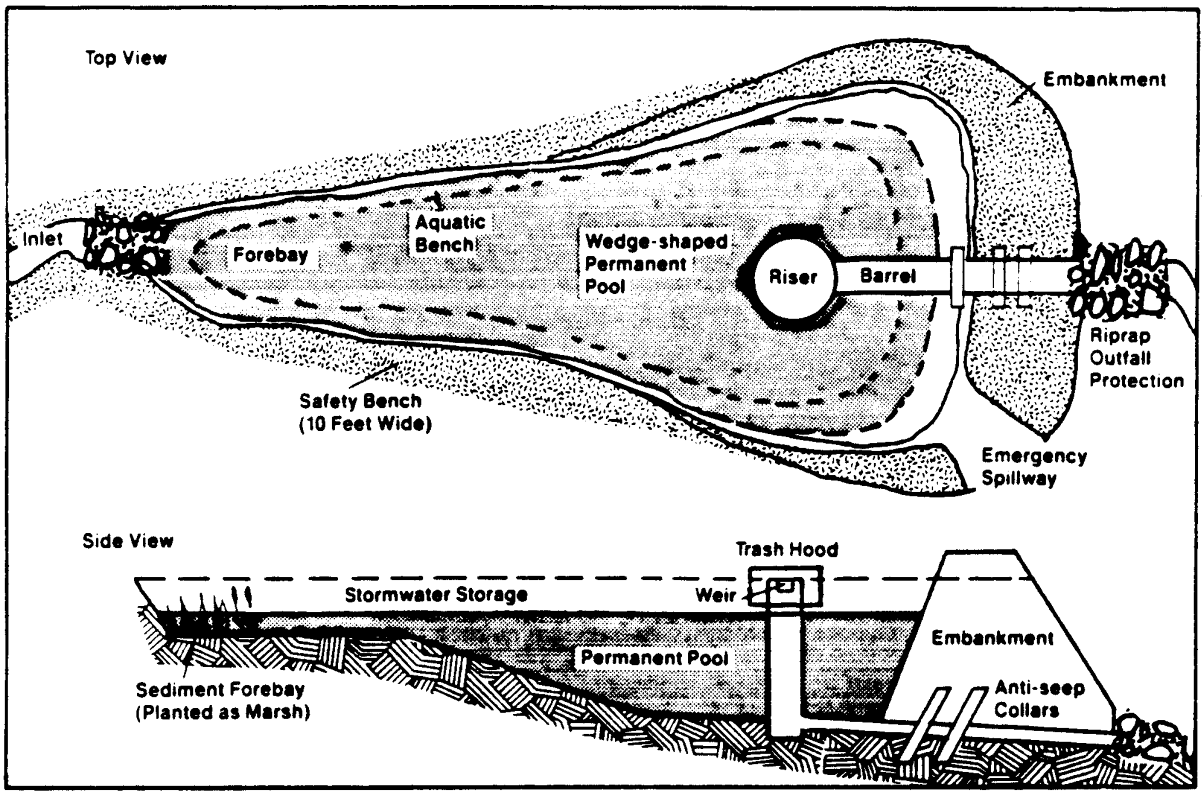
(d) A sediment sump or forebay should be considered as a design feature for water quality treatment. This design aspect facilitates sediment removal by concentrating sediments in a small area at the inlet to the pond. The installation of velocity dissipators at the inlet are essential to ensure the deposition of sediment in the forebay section. This also helps to reduce the cost of sediment removal because the sediments are concentrated in shallow areas at the head of the pond, not in deep water. The shallow sill between the sediment forebay and the deep portion of the pond can be planted as a shallow marsh to aid in additional capture of fine sediments and uptake of soluble pollutants (see Figure 4.1).

4.5 Depth

(a) The depth of the pond should be variable, with the average depth between 3 and **6** feet. **It** is important to integrate deeper portions of the pond with the shallow vegetated areas to allow predacious insects and fish to prey on nuisance insect species such as mosquitoes.

(b) The deep section of the permanent pool should have a minimum depth of 3 feet. This prevents resuspension of sediments and other contaminants into the water column by wind turbulence.

Figure 4.1 Schematic of a Wet Pond. (Source: Schueler, 1987)



(c) The maximum recommended depth of the permanent pool is **10** feet. Ponds deeper than this depth may be subject to stratification and promote anoxic conditions at the pond bottom, releasing sediment-bound pollutants into the water column.

(d) A littoral (shoreline) shelf should extend from the permanent pool edge in towards the center of pool with slopes of 6:1 or flatter. This shelf functions as a safety bench by providing shallow water at the permanent pool edge and should extend a minimum of 10 feet **in** towards the pool. If this shelf cannot be provided then the pond should be fenced to restrict public access (subject to local ordinances).

(e) A least 25%, but no more than 30%, of the surface area of a pond should be _ 18 inches deep to promote wetland plant colonization along the pond edge. A layer of organic soil (6 inches thick) is recommended to promote the establishment of wetland vegetation. Contractors should guarantee planting 100% survival rate for all plantings around or within the basin for one fill growing season to include the spring and fall seasons. These wetland plants assist in trapping sediments from overland flow and increase the opportunity for nutrient uptake. The aquatic vegetation along the fringe of the pond also helps to stabilize the pond shoreline and prevents erosion along the bank. In addition, the vegetation conceals trash and floatable debris from outside the facility.

4.6 Slopes

(a) Basin side-slopes leading down to the permanent pool edge should be 3:1 or flatter. This requirement facilitates access for maintenance and mowing of basin slopes and minimizes slope erosion. If site constraints prohibit slopes of 3:1 or flatter, then proper stabilization and fencing are recommended for steeper slopes to reduce hazards and increase public safety. Site constraints must be clearly documented by the applicant and a narrative provided as **to** why 3:1 slopes cannot be constructed.

(b) Safety bench slopes should be 6: I or flatter, as described above in 5.5(d).

(c) Submerged slopes beyond the safety bench should be no steeper than 2:1.

(d) All side-slopes upland of the permanent pool are to be properly stabilized with grasses (Tall fescue or Reed Canary), immediately following basin excavation. This prevents erosion and washouts, which can result in premature sediment accumulation within the pond and subse9uent blockage of outlet channels and structures.

4.7 Inlet and Outlet Structures

(a) Appropriate splash guards and erosion control are required at all inlets to prevent unnecessary gouging and pooling of water below the inlet. These devices must extend at least to the permanent pool elevation, preferably lower. Outlet protection is also required at all discharge points of the stormwater facility, including the emergency spillway. Appropriate design guidance for outlet structures is found in Chapter 6, Section F of the most recent version of the Rhode

Island Soil Erosion and Sediment Control Handbook.

a) The invert elevation of the inlet structure should be located within 1 foot of the permanent pool elevation and be constructed with rip-rap or cement slabs to eliminate erosion along the flow path **into the** permanent pool.

(c) The channel below outfalls shall be designed to be stable against the maximum design flow (discharge) from the facility and its' emergency overflow device.

(d) The preferred outlet structure is a riser with barrel outlet design. Anti-seep collars should be placed around the barre' in the embankment to prevent water in the pond from leaking around the barrel, Where possible, the riser should be placed within or on the embankment rather than in the middle of the pond to facilitate maintenance and inspection of the structure, but this may require fencing for safety purposes. Reinforced concrete pipes, risers, and barrels should be utilized, rather than corrugated metal, to reduce future maintenance due to metal corrosion and provide better longevity.

(e) The lowest orifice of the outlet structure must have a trash rack or a negatively sloped pipe drawing water at least I foot below the surface, to prevent clogging from floatable debris.

(f) Orifices should be placed on the riser **to** accommodate the predevelopment discharge rates for the 2-year, 25-year, and l00-year& runoff events, where applicable.

(g) Hoods or trash racks shall be installed on all orifices or pipes less than 24 inches in diameter to prevent clogging and disruption of outflow from trash or debris.

h) A drain-down valve should be included in the pond outlet structure to allow for complete draining of the pond within 24 hours for emergency purposes or routine maintenance procedures. This valve must be secured through a lock mechanism to prevent vandalism or accidental draining of the pond. Other drain methods may be used pending approval by the permitting agency.

(i) All basins must have an emergency outlet to accommodate storm flow volumes in excess of the 100 year storm or the largest storm intensity for which the basin was designed. The recommended outlet should be a weir, with the invert of the weir a minimum of 1 foot below the top of the embankment. The outfall for this emergency spillway must have erosion prevention devices as noted above.

4.8 Maintenance and Other Considerations

(a) Access must be provided for the purpose of maintenance, through a right of way into the facility. The access should be a minimum of 15 feet wide, have profiles no steeper than 5:1, and must not cross the emergency spillway outlet.

(b) Basin side-slopes above the permanent pool and meadow areas should be mowed at least once per year (preferably after August 15th) to eliminate woody shrubs and trees. In addition, all trash and floatable debris should be removed from the facility during routine mowing.

(c) On-site disposal areas capable of receiving dredged sediment from the facility should be reserved in adjacent open lands if off-site disposal is not feasible. This area should have sufficient capacity to accommodate the volume of at least two clean-out cycles. The sediment may have **to** be tested for heavy metals and other contaminants if stormwater facilities are located in industrial, heavy commercial or major highway areas. If sediments contain high levels of contaminants they may have to be transported to a proper disposal site such as a sanitary landfill.

(d) Inspection of the pond and all inlet and outlet structures should be performed at least on an annual basis, preferably during a storm event to inspect for proper functioning of the facility.

(e) Trees or shrubs should not be planted on any impounding embankments (i.e., dikes or berms). Such plantings increase the likelihood of impoundment failure due to root decay and subsurface disturbance. Grasses (e.g., tall fescue) should be the only acceptable vegetation for planting and stabilizing impounding embankments.

(0 Grasses must be planted around and within the basin immediately following construction to stabilize the slopes and prevent erosion. Trees and shrubs should not be planted on any impounding embankments, to prevent potential subsurface disturbance and possible failure of the structure. It is suggested that the applicant use Stormwater Basin Plants and Landscaping Guide: A Simple Guide for Designers and Communities (LMP, 1991) to assist in the selection of appropriate vegetation.

(g) Sediments should be removed from the basin during the first (initial) year of operation and every 10 years thereafter. More frequent removals will be necessary if the sediment storage capacity of the forebay is exceeded.

(h) The grassed areas of the basin should be inspected at least twice per year to check for erosion problems. Problem areas should be reseeded immediately to stabilize exposed soils, thereby preventing erosion and potential clogging of outflow devices.

SECTION 5

EXTENDED DETENTION PONDS

5.! Introduction

Extended detention ponds are very useful for controlling excessive peak discharge rates and improving runoff water quality. This type of BMP is only slightly more expensive than a standard flood control detention basin, the difference being an outflow device to maintain extended detention times. Oftentimes, existing detention basins can be easily retrofitted with a new outflow device to achieve the required extended detention period necessary to improve water quality. These basins also help to reduce the occurrence of erosive downstream floods by controlling the discharge rates of runoff from both small and large storm events.

The requirement for these basins to be designed and constructed as a two stage facility increases the efficiency of the system. The upper stage is used to store the runoff from infrequent large storms, while the lower stage detains the runoff water quality volume from the site. This lower stage is managed as a shallow marsh or wet meadow, which in turn improves uptake of soluble pollutants (e.g., phosphorus and nitrogen). Planting Reed Canary grass and other wetland adapted plants in the lower stage will enhance the pollutant removal capability of the facility. These lower stage areas also create wetland and wildlife habitat, while providing valuable environmental benefits.

5.2 Site Suitability

(a) Extended detention ponds are useful for developments that are not large enough to support a typical wet pond facility (i.e., less than 10 acres), however, this does not preclude larger development sites from using extended detention basins. Where possible, wet ponds are preferred over extended detention basins due to their greater capability for removing soluble pollutants.

b) Ponds cannot be constructed in existing stream channels, wetlands or other waters of the State without approval by the permitting agency, nor should they receive permanent or continuous flow from any surface water body.

(c) Ponds should not be located in areas that receive discharge from springs or subsurface groundwater flow.

(d) There should be a separation distance of at least 25 feet between the basin and the property boundary of the nearest lot. This separation distance creates a safety buffer between the basin and adjacent properties. This distance may be reduced with proper fencing or landscaping.

(e) Basins should not be located within 50 feet to any component of an individual sewage disposal system (subject to SD 3.00 of the **DEM 1SDS** regulations).

(f) Basins cannot be constructed in utility right-of-ways (e.g., sewer or electric lines) without obtaining written authorization (easement).

5.3 Design Procedures

(a) Extended detention basins are best suited as a combined peak discharge control and water quality improvement facility, therefore the guidelines for detention basin design and construction provided in the most recent version of the Rhode Island Soil Erosion and Sediment Control Handbook must be followed. Furthermore, the guidelines in Earth Dams and Reservoirs. Technical Release Number 60 published by the Soil Conservation Service (1985) should be followed when designing and constructing basins with impoundment (i.e., berm or dike) structures.

(b) The basin should be designed as a two stage facility, with the upper stage sized to contain the runoff from the 2-year, 25-year, and 100-yr storms (where applicable), while the lower stage has the capacity for the water quality volume (see Figure 5.1). The lower stage should be managed as a wet meadow or shallow marsh to improve biological removal of soluble pollutants, such as phosphorus and nitrogen.

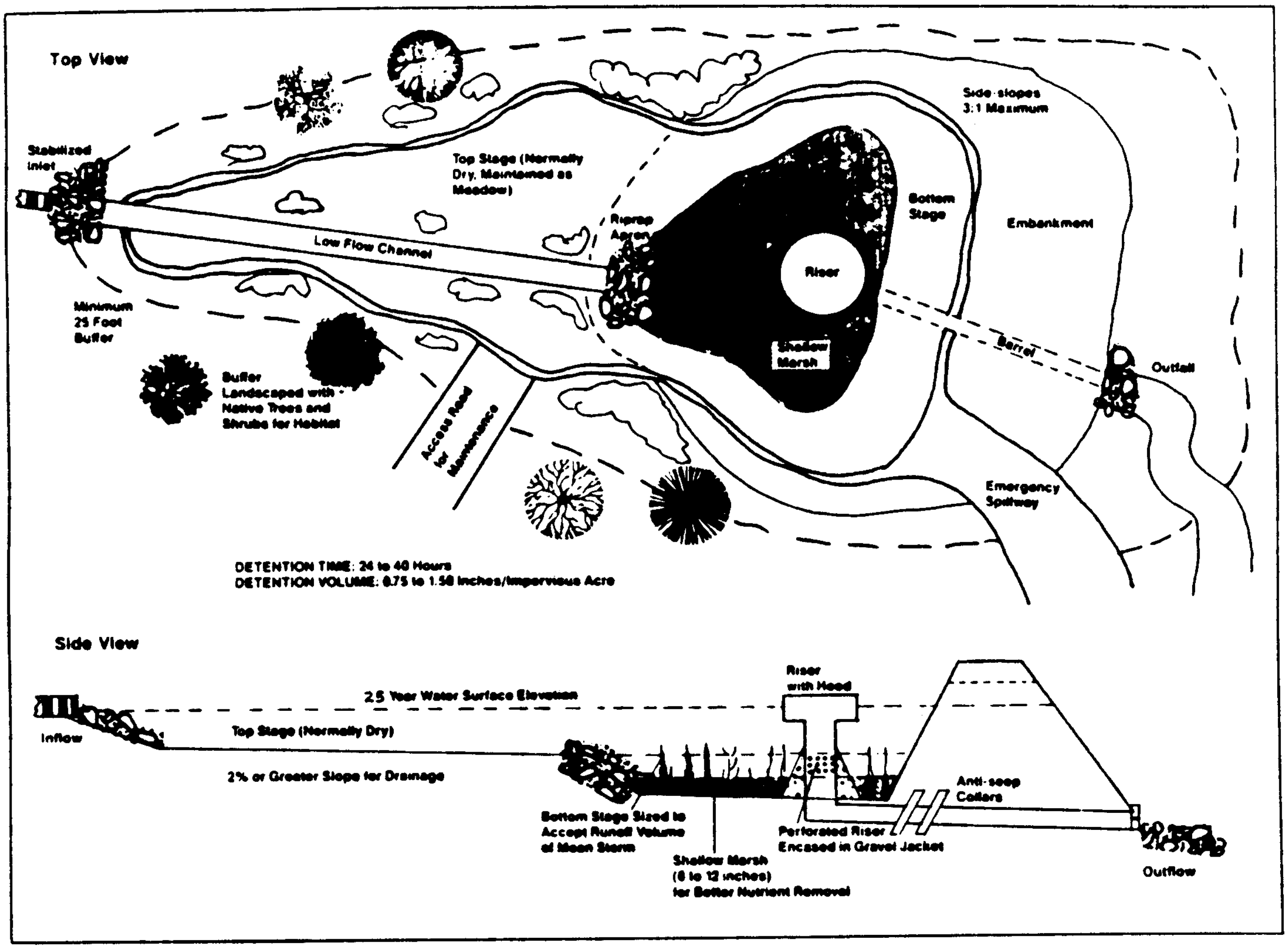
(c) The minimum volume of the pond must be **equal** to the water quality volume (WQV) which is determined by multiplying **I** inch by the area of impervious surfaces within the contributing drainage area. The outlet structure must **be** designed to provide extended detention of this volume for a minimum of 36 hours. The detention period is defined **as** an average drain-out time, whereby the water quality volume is released over a **36** hour period. The **following** method can be used to calculate the size of the required **orifice:**

$$A = Q / Cd(2gh)^{1/2}$$

where;

A = orifice area (ft^2)
Q = average rate of **discharge (cfs)** = **WQV** / 129,600 seconds **(36** hours)
WQV(ft') = impervious area (ft^2) / 12
g = gravitational constant (32.2 ftisec^2)
h = average depth of water above the center of orifice (ft), where h = (maximum elevation of WQV stage - elevation of center of orifice) divided by 2
Cd = orifice coefficient (assumed = 0.6)

Figure 5.1 Schematic of Extended Detention Pond Design Features (Source: Schueler, 1987)



(d) The preferred outlet structure for maintaining extended detention times is a perforated riser encased in a gravel jacket (see Figure 5.2). The perforations in the riser should be covered with galvanized or stainless steel wire mesh. The mesh openings should be one-half the diameter of the gravel jacket material. Wire mesh should be wrapped around the riser before the gravel jacket is applied. The combination of fine wire mesh and the gravel jacket helps prevent clogging of the small diameter orifices in the riser. The total area of all the perforations regulates the detention time within the basin. Other outflow devices may be acceptable if they have an above ground cap to facilitate clean-out of the pipe and meet permitting agency approval. Figure 56.2 illustrates examples of acceptable outflow structures that regulate detention times for stormwater within the basin. The applicant must supply calculations and/or manufacturer's information regarding the proposed outlet device and its' associated discharge rate and detention time(s).

(e) The minimum length to width ratio of the basin should be 3:1 (length to width). This dimension requirement promotes 'plug flow" of incoming stormwater runoff, reduces wind mixing of bottom sediments, and improves pollutant removal, If this length to width ratio cannot be achieved due to site constraints, then alternative designs using baffles etc., will be considered by the permitting agency. The main idea is to have the longest flow length possible.

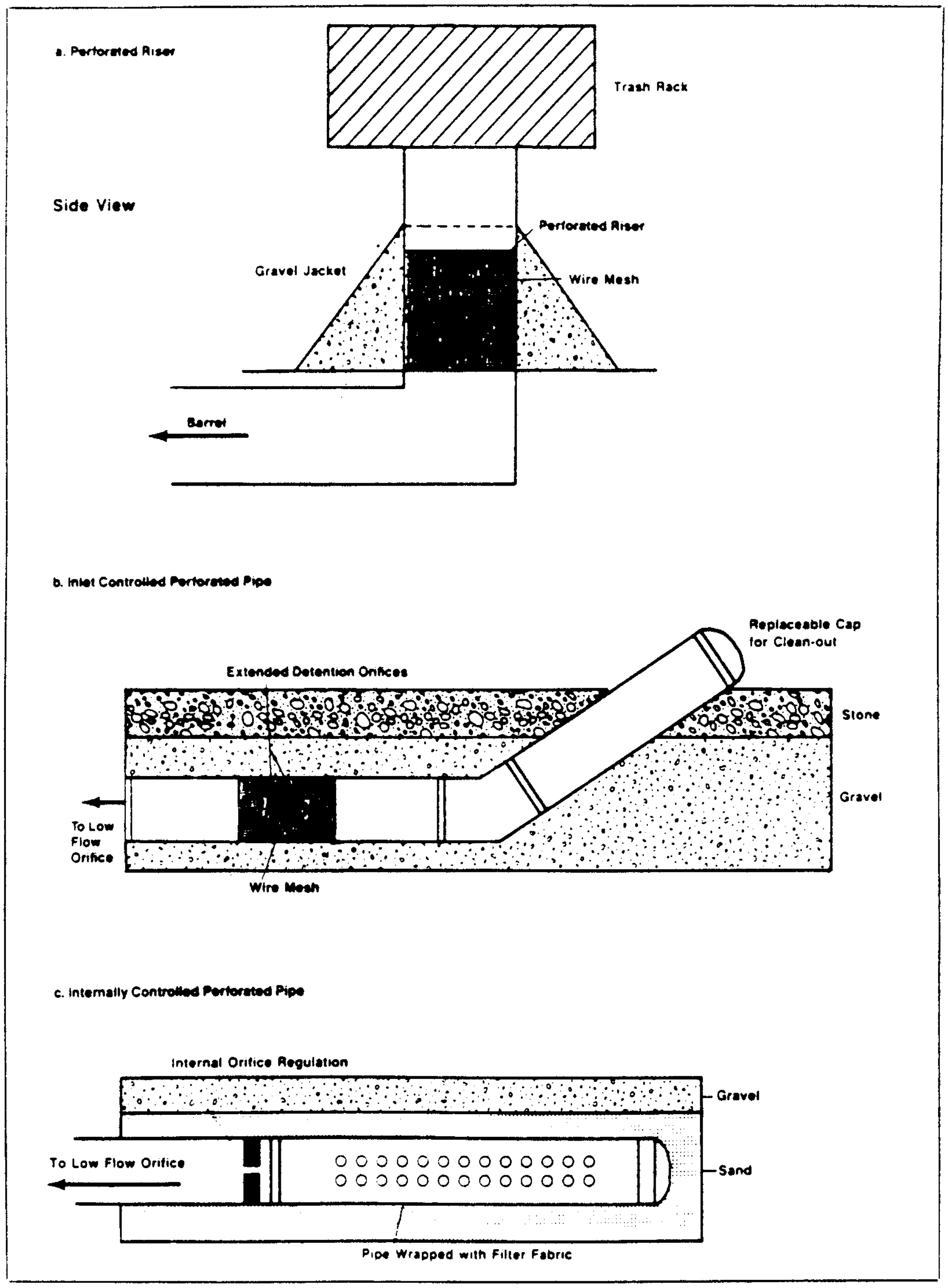
(0 The design bottom of the basin should not be closer than 12 inches to the seasonal high water table elevation unless an impermeable geomembrane is utilized. This provision reduces the opportunity for contaminants in the basin bottom from coming into contact with the water table and causing contamination of local groundwater.

(g) A 6 inch layer of organic soil should be added to the lower stage floor to promote wetland plant growth.

(h) All side slopes leading into the basin should be 3:1 (horizontal to vertical) or flatter. If site constraints prohibit slopes of 3:1 or flatter, then proper stabilization and fencing are recommended for steeper slopes to reduce hazards and increase public safety. Site constraints must be clearly documented by the applicant and a narrative provided as to why 3:1 slopes cannot be constructed.

(i) There should be a low flow channel through the top stage, extending from the inlet to the lip of the lower stage. This channel should be constructed of rip-rap (or other appropriate protection) to prevent scouring and erosion of the basin floor. In addition, there should be a rip-rap apron at the down-slope end of the channel. This apron serves to dissipate erosive flow velocities, reduce the potential for particle resuspension, and prevent scouring of the lower stage floor.

Figure 5.2 Methods for Extending Detention Times in Dry Ponds (Source: Schueler, 1987)



j) A sediment sump or forebay should be considered as a design feature at the inlet to the basin. The forebay will reduce sediment removal costs by concentrating sediments in a small area, thereby facilitating maintenance. Furthermore, it reduces the opportunities for sediments to clog the outlet structure by capturing sediments at the inlet end of the basin.

(k) The inlet to the basin must have a velocity dissipator device to reduce erosive flows. This device shall be constructed of rip-rap, concrete gabions, or other materials subject to permitting agency review.

Q) The upper stage floor should be uniformly graded with slopes of at least 1 percent but no greater than *5* percent from the inlet to the lip of the lower stage. The lower stage basin floor should be as level as possible to maintain equal depths of water within the basin.

(m) All extended detention basins must have outlet structures, splash pads, and an emergency spillway constructed as specified in the wet pond section of this manual. Appropriate design guidance for outlet protection is found in Chapter 6, Section F of the most recent version of the <u>Rhode Island Soil Erosion and Sediment Control Handbook</u>.

(n) A maintenance right-of-way with a minimum width of 15 feet must be provided for access into the basin for inspection and maintenance. This right-of-way may not cross the emergency spillway channel.

5.4 <u>Maintenance</u>

(a) Grasses must be planted around and within the basin immediately following construction to stabilize the slopes and prevent erosion. Trees and shrubs should not be planted on any impounding embankments, to prevent potential subsurface disturbance and possible failure of the structure. It is suggested that the applicant use <u>Stormwater Basin Plants and Landscaping Guide: A Simple Guide for Designers and Communities</u> (LMP, 1991) to assist in the selection of appropriate vegetation.

(b) Side-slopes, embankments, and the upper stage of the basin should be mowed at least once during the growing season (preferably after August 15th), to prevent unwanted woody growth. Mowings can be more frequent in residential areas if a more groomed appearance is desired and the basin is not managed for wildlife habitat. All trash and litter shall be removed from the basins during mowing operations.

(c) Sediments should be removed from the basin during the first (initial) year of operation and every 10 years thereafter. More frequent removals may be necessary if the sediment storage capacity of the forebay or pond is exceeded.

(d) The outlet structure and all outflow channels should be inspected annually. Furthermore, extended detention devices should be inspected at least twice per year. Inspections should be accomplished several times during the first six months of operation, especially after rainfall events to check for clogging or, conversely, too rapid of a release.

(e) The grassed areas of the basin should be inspected at least twice per year to check for erosion problems. Problem areas should be reseeded immediately to stabilize exposed soils, thereby preventing erosion and potential clogging of outflow devices.

(f) An area should be set aside within the development site for the purpose of sediment disposal if an off-site disposal area is not feasible. This site can also serve as open space and recreation areas. The area must be large enough to handle the volume of at least two clean-out cycles. The sediment may have to be tested for heavy metals and other contaminants if stormwater facilities are located in industrial, heavy commercial, or major highway areas. If sediments contain high levels of contaminants they may have to be transported to a proper disposal site such as a sanitary landfill.

SECTION 6

GENERAL REQUIREMENTS **FOR** INFILTRATION PRACTICES

6. Introduction

This section provides guidance on the following infiltration methods referred to herein: (1) Basins, (2) Trenches, and (3) Dry Wells. On large development sites (greater than 5 acres) a series of smaller infiltration facilities may be preferred in the upper portions of a site, rather than one large basin located at the lower end of the contributing drainage area. This provides better water quality (greater capture of 'first flush pollutants) control and management of on-site stormwater flows. Sediments should be removed from stormwater before it enters infiltration structures to prevent clogging and possible failure. For most infiltration systems this requirement can be accomplished by installing over-sized catch basins, sediment control basins, or oil/water separators of sufficient storage capacity. See Section 7 for pretreatment practices.

Siting considerations are important with respect to the use of stormwater management practices that involve infiltration. The process of infiltration, while often deemed more protective of surface water quality, creates a situation in which pollutants may be more readily transported into groundwater. Additionally, while routine stormwater discharges into infiltration systems may present low risk, the presence of an infiltration system can provide a direct route of serious contamination in the event of a spill or inadvertent release of oil, gasoline, or other hazardous materials. Consequently, the risks associated with infiltration practices should be carefully weighed in locations designated as wellhead protection areas (WHPA5) or in other areas where groundwater is used as a drinking water supply.

In certain situations separating the water quality volume from all additional stormwater runoff is referred to as 'flow splitting". The goal is to capture and provide treatment for the first flush of pollutants (i.e., the water quality volume), while additional stormwater runoff is directed to a detention basin (off-line storage facility). This method allows the water quality volume to exfiltrate through the basin and be treated, while all additional runoff volumes are controlled by the outlet structure and discharged from the detention basin at pre-development rates. This approach is encouraged to help meet objectives of both surface water quality improvement and peak discharge control.

6.2 Groundwater Protection

(a) The OEM Groundwater Section is responsible for coordinating and implementing statewide programs aimed at protecting groundwater quality. These programs include regulations governing discharges to groundwater. Therefore, most proposals for the subsurface disposal of stormwater must be submitted to the OEM Division of Groundwater, Underground Injection Control (UIC) Program to ensure the proposal meets the program requirements under current rules. Commercial and industrial applicants must obtain an Order of Approval from the Groundwater Division prior to construction of the subsurface stormwater disposal system.

Proposals for similar systems in residential subdivisions must be reviewed by the UIC Program, but an Order of Approval is not necessary provided the minimum standards of the UIC program are maintained. The following design and installation standards should be incorporated with proposals for the disposal of stormwater runoff via infiltration methods.

6.3 Site Suitability

(a) Infiltration methods should generally be limited to soils in hydrologic group A or B only, as identified in the Soil Survey of Rhode Island (Rector, 1981) unless subsoil testing and analysis confirms that the minimum infiltration rate can be obtained. However, drywells proposed for individual residential dwellings may be permitted for hydrologic group C soils.

b) Subsurface investigations are required to define the suitability of soils for subsurface disposal of stormwater runoff. These explorations are necessary to determine the textural characteristics of the various soil strata, restricting layers, location of the seasonal high water table elevation and depth to bedrock in the location of the proposed system.

(1) It is recommended that a qualified soil scientist, engineer, or comparable professional identify the soil through examination of the soil profile in the location of the proposed system. In addition, the following determinations should be included in the investigation:
soil textures, estimation of soil percolation rates at the infiltration device design depth, soil hydrologic group, estimation of seasonal high water table elevation by identifying soil gleying and mottling, and identification of any restricting layer(s).

(2) Test procedures for determining groundwater table elevations can also be accomplished in accordance with the procedures outlined in SD 17.00 of the DEM Individual Sewage Disposal Systems regulations.

(3) The preferred method for investigating soil suitability is with a test pit, dug to a depth no less than 5 feet below the design bottom of the infiltration device(s) or to the static water level, to inspect and describe the soil profile. A minimum of one inspection pit must be dug per 5000 **square** feet of infiltration bottom area. All inspection pits must be located within the perimeter of the infiltration system. This type of investigation is necessary because of the potential variability of soils within any specific site. This investigation enables the soil scientist or engineer to characterize the soils on-site as accurately as possible and will greatly assist in placing infiltration systems on the most suitable soils of the site.

(4) The applicant should assess the potential effects from the subsurface disposal of stormwater on adjacent road surfaces, building foundations, embankments, and any other site feature that may be sensitive to groundwater flow.

6.4 Determining Infiltration Rates

(a) The preferred method to determine infiltration rates is with the use of a double ring infiltrometer test procedure. This method produces more accurate results and a more true representation of the soil's infiltration rate than the percolation test results. Ring infiltrometers eliminate the sidewall component of water movement, so the results obtained represent only downward movement of water. Percolation test procedures should be conducted when site constraints (e.g., very stony soils) limit the use of the double ring infiltrometer method. Tests to establish infiltration rates are to be conducted within the perimeter of the area for the proposed infiltration device(s). The rates obtained from this test will assist in generating the required dimensions for the infiltration device(s). Alternate standard methods are also acceptable. The applicant must submit all information and data collect for any method used to establish percolation rates.

(b) Persons qualified to test are professional soil scientists, engineers, land surveyors and sanitarians.

6.6 Design Requirements

(a) The minimum volume of the infiltration system must be based on the volume of water obtained by multiplying 1 inch by the impervious surface of the contributing area (i.e., depth times area = volume). This volume is referred to as the 'water quality' volume and generally contains the "first **flush" of** pollutants transported from the contributing area during the initial portion of the storm event. **It** is not economically feasible nor practicable to size infiltration systems to handle runoff volumes from large storms such as 25- or 100-year events. Therefore, infiltration systems should treat the initial water quality volume, with all additional flows directed to an appropriate water quantity and peak discharge control structure, if detention is warranted on the site.

(b) The design of the system must be based on the slowest rates (inches/hour) obtained from the infiltration/percolation tests performed at the site. These infiltration rates assist in determining the depth of the system that insures complete infiltration of stormwater runoff within a 72 hour time period.

(c)The minimum acceptable soil infiltration rate for use of infiltration systems shall be 1.0 (in/hr) and the maximum design infiltration rate is considered to be 7.5 (in/hr).

(d) The maximum allowable ponding or storage time for infiltration systems is 72 hours.

(e) The soil in the location for the proposed infiltration system should not be compacted by construction-related activities. This will necessitate roping off the areas of proposed systems to prevent machinery from compacting the soils.

(f) Infiltration systems should not be allowed to receive runoff until the entire contributory drainage to the infiltration system has received final site stabilization.

(g) The design should provide for an overflow system with measures to provide for non-erosive velocity of flow at the outfall and along the length of any outfall channel as necessary to achieve a non-erosive velocity of flow from the structure to a water course.

(h) For sites with pre-east cement galleys being utilized for **the** infiltration structure, each line of galleys **should** have at minimum two inspection man-holes for access and maintenance, located at opposite ends of the line.

(i) Infiltration structures should typically not be located in soils where slopes exceed 20 percent. Furthermore, structures should not be placed in fill materials due to the possibility of creating an unstable subgrade, especially on sloping sites.

6.7 Separation Distances

(a) The following are suggested separation distances, however, the proper DEM programs should be contacted for the appropriate requirements.

(1) A minimum separation distance of 3 feet should be maintained between the design bottom of the structure and the seasonal high water table.

(2) If the actual soil infiltration rate is greater than 7.5 inches per hour, then the separation distance to the seasonal high water table should be increased to 4 feet.

(3) A minimum separation distance of 5 feet should be maintained between the design bottom of the structure and bedrock, regardless of the infiltration rate.

(4) No infiltration structure should be closer than 100 feet to any component of a septic system.

(5) A minimum setback of 400 feet should be maintained from all community wells. Additional setback distance may be required by the **DEM,** depending on hydrogeologic conditions.

(6) A minimum setback from non-community and private wells should be 100 feet. Additional setback distance may be required by the **DEM,** depending on hydrogeologic conditions.

(7) A 25 feet separation distance to a water line (unless the line is sleeved) should be maintained.

(8) The minimum setback to surface drinking water supplies and their tributaries should be 200 feet.

(9) All systems shall have a minimum setback of 50 feet to coastal features as defined in **the** RJCRMP (refer to Section 140 of **the RICRMP). The CRMC** may require more stringent **setbacks** from coastal waters or features.

(10) No system **should be** closer than 50 feet to any surface water(s) or coastal wetland(s), not included in **7.7(a)(8)** and (9), above. The Division of Freshwater Wetlands may require more stringent setbacks in riverbank wetlands or other **sensitive** areas.

(11)Infiltration systems should be placed no closer than 20 feet to any building foundation to protect structural integrity. Large scale infiltration systems may require larger set back distances. Also, if the foundation floor is below the discharge invert, a greater set back may be warranted.

6.8 Pretreatment

(a) Runoff should be pretreated prior to entering the infiltration structure to prevent sediments, oil, and other debris from clogging the internal soil surfaces and reducing the infiltration rate. If clogging of the infiltrative surface occurs it may cause the system to fail, resulting in costly repairs or replacement. Therefore, pretreatment is generally a necessity and can be accomplished through the use of over-sized catch basins, sediment control basins, sand filters, or oil/water separators of sufficient sediment storage capacity for subsurface systems and infiltration basins. Vegetative filter strips (minimum 20 feet length) *may* be required for pre-treatment of stormwater entering surface-exposed trenches. These pre-treatment methods capture and retain the bulk of sediment loads prior to runoff discharge into the infiltrative area (see Section 7 on pretreatment).

6,9 Maintenance and Responsibilities

(a) The property owner is responsible for any soil and groundwater contamination resulting from the use of stormwater runoff subsurface disposal systems.

(b) The existence of the subsurface disposal system should be recorded on the property deed at the local municipal office. All operational and maintenance requirements, including legal responsibilities, where applicable, should also be recorded on the title.

(c) The disposal system(s) should be inspected and cleaned at least yearly with all oil and debris removed and disposed of properly in accordance with state and federal regulations. In the case of an oil or bulk pollutant release, the system should be cleaned immediately following the spill and the DEM Division of Site Remediation should be notified. For the purpose of oil removal a licensed contractor may be necessary for the removal, transport, and disposal of waste oil products to a properly licensed facility.

(d) All vegetative filter strips should be maintained as specified in Section 10.

6.10 Spill Procedures

(a) See section 7.2(c) for proper actions.

SECTION 7

PRETREATMENT DEVICES

7.1 Introduction

Stormwater runoff should be treated before it enters any infiltration device. This requirement reduces or eliminates the opportunities for system failure by removing the major portion of sediments, oils, grease, or other substances that can clog infiltrative surfaces. Pretreatment may also be necessary to reduce pollutant loadings to groundwater. The following information on pretreatment devices is provided to assist designers to reduce overall maintenance costs and ensure proper system functioning.

7.2 Oil/Water Separators

Oil-water separators are essentially large tanks that help to trap sediments and segregate hydrocarbons from runoff water before being discharged into a subsurface stormwater disposal system. These tanks are multi-chambered to assist in the separation process and improve the quality of stormwater runoff. An oil/water separator has a function similar to a septic tank, whereby most solids (sediment) and scum (oil) are removed prior to effluent reaching the leaching area. Oil/water separators are often necessary to retreat stormwater runoff and prolong the useful life expectancy of a subsurface disposal System.

Oil/water separators are required for many subsurface stormwater disposal systems. The following oil/water separator design was developed by DEM to provide guidance to engineers. The DEM acknowledges that other designs, in particular for smaller scale development projects, may be appropriate. DEM approves oil/water separator designs through the UIC, RIPDES, and Freshwater Wetlands programs.

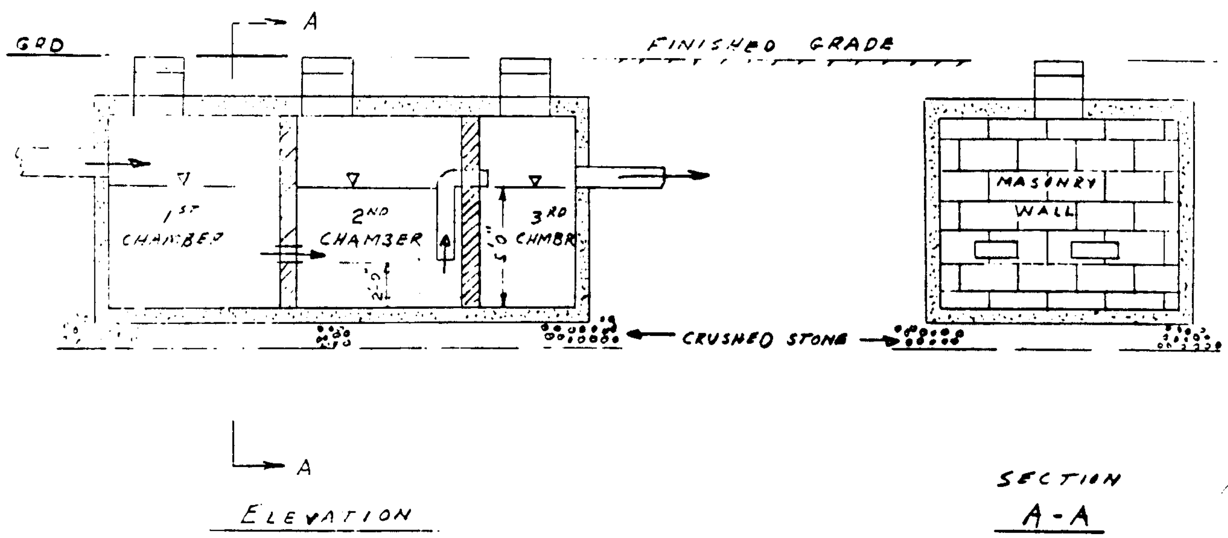
(a) Design Requirements

(I) Oil/water separators should be a three chamber design (see Figure 7.1) with the first and second chambers having a combined volume equal to 400 cubic feet per contributing impervious acre. In addition, the minimum depth of the permanent pool in these chambers will be no less than 5 feet.

(2) The walls separating the chambers must be water tight and only allow passage of stormwater through the design ports or pipes (see number 6 below for sizing requirements). There shall be no additional vents or passageways within the walls.

(3) All tank joints and pipe connections must be made water tight with non-shrinking grout.

Figure 7.1 Recommended Oil-Water Separator Design. (Schematic by Henry Sardelli, P.E. based on Schueler, 1987)



OIL - WATER SEPARATOR

(4) All hardware and piping within the tank should be galvanized, corrosion resistant, or stainless steel. Pipes made of PVC are acceptable and in some applications may be preferable, however, these pipes must be constructed of schedule 40 or greater.

(5) Each chamber must be constructed to include a manhole cover to allow access and venting.

(6) There should be two inlets in the wall between the first and second chambers. Each individual port will be equal to the area of the inflow pipe entering the first chamber and be covered with a trash screen in the first chamber. Furthermore, the invert of the two ports should be 2 feet from the bottom of the chamber.

(7) The bottom of the elbow pipe in the second chamber should also be 2 feet from the bottom of the chamber. Additionally, the diameter of this pipe should be larger than the diameter of the inflow pipe entering the first chamber.

(8) The outflow pipe in the third chamber should also have a diameter larger than the inflow pipe into the first chamber.

(9) The inflow pipe should be constructed and sized to pass the water quality flow rate into the oil/water separator. All additional flows should be passed through another pipe into a detention facility of sufficient capacity to meet applicable peak discharge control requirements.

b) Maintenance Requirements

(1) The oil/water separator should be inspected and cleaned at least once yearly with all oil and sediments removed and disposed of in accordance with state and federal guidelines. In the case of an oil or bulk pollutant release, the system must be cleaned immediately following the spill. All costs incurred for maintenance, cleaning, and inspection are the responsibility of the property owner and/or responsible party. In certain cases, the appropriate DEM program may require documentation of maintenance.

(2) The existence of the oil/water separator should be recorded on the property deed at **the** local municipal office. All operational and maintenance requirements, including **legal** responsibilities, should also **be** recorded on the title.

(c) Spill Procedures

(I) Any inadvertent or deliberate discharge of waste oil or any other pollutant to the stormwater disposal system requires immediate notification of the DEM Oil Pollution Control Program at 277-2284, as per **Oil Pollution** Control Regulations. During non-working hours notification of spills can be made to the DEM Division of Enforcement at 277-3070, the 24-hour emergency response phone number.

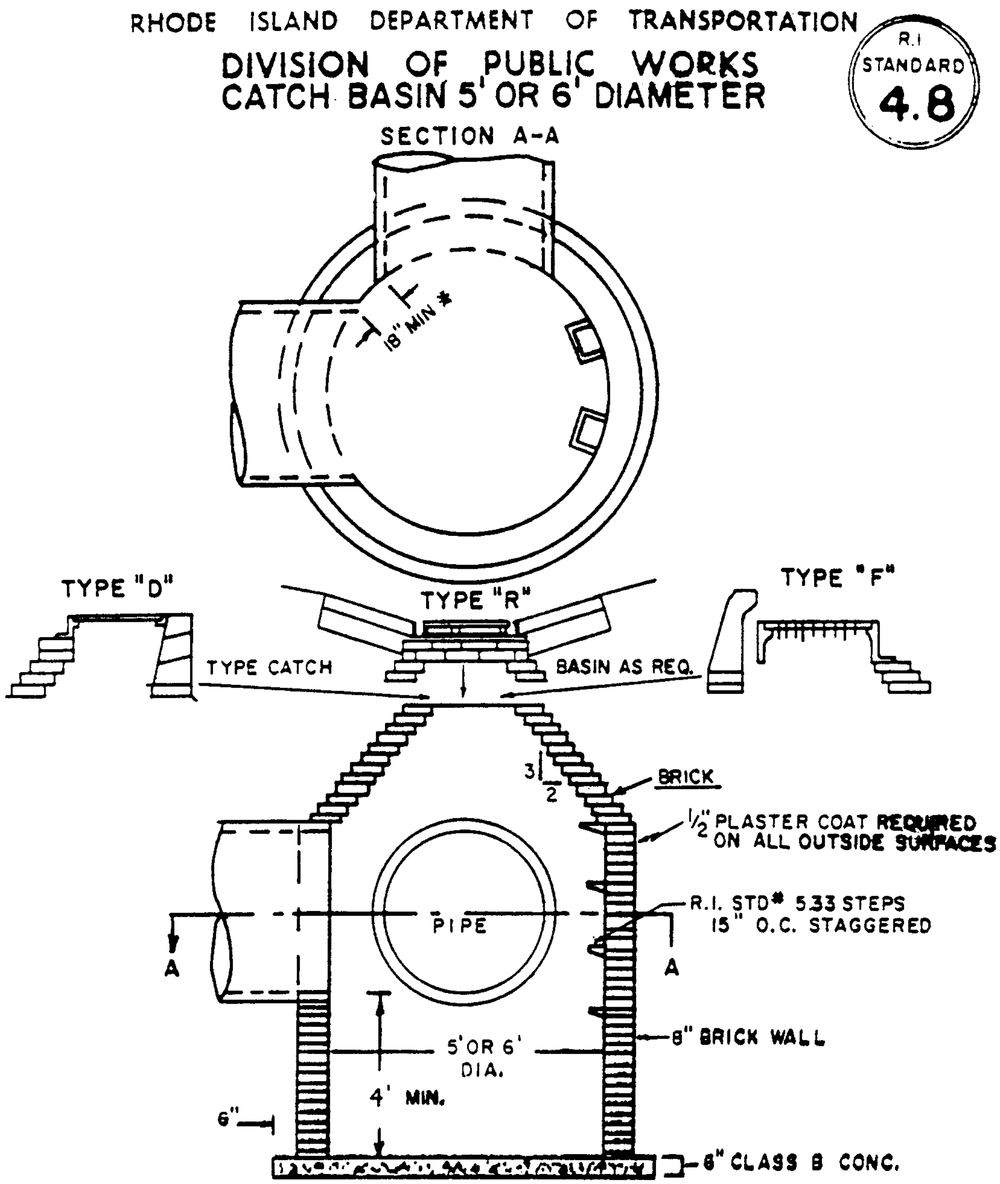
(2) Any incident of groundwater contamination resulting from the improper discharge of pollutants to the stormwater disposal system shall be the responsibility of the property owner as well as any other parties that the DEM determines to be responsible for the contamination. Pursuant to state laws and regulations, the DEM may require the property owner and other responsible parties to remediate any incidents that may adversely impact groundwater quality.

(3) Upon transfer of the property, the new owner should be informed as to the legal responsibilities associated with the disposal system, as indicated above.

7.3 Over-sized Catch Basin

This type of device can be useful to segregate sediments from stormwater runoff. Figure 7.2 illustrates an over-sized catch basin (please note that the design sump is 4 feet). In some cases, especially for small scale applications, over-sized catch basins can be modified as an oil-water separator with the addition of an elbow pipe. Any design will have to be approved by the permitting agency.

Figure 7.2 Typical Over-Sized Catch Basin Design. (Source RIDOT, 1982)



* THE MINIMUM DISTANCE BETWEEN PIPES ENTERING THE CATCH BASIN MUST BE 18". THE SIZE OF THE CATCH BASIN WILL BE DETERMINED BY THE PIPE SIZE AND ENTRY ANGLE, AND WILL BE NOTED ON PLANS AND IN THE TABLE OF QUANTITIES.

SECTION 8

INFILTRATION BASINS

8. 1 Introduction

Infiltration basins are generally constructed by excavating a pit downward into permeable soils with acceptable infiltration capabilities. Some basins are constructed using a dam to impound runoff within the basin facility. Stormwater runoff directed into the basin is infiltrated through the basin bottom and side walls. This process of filtration helps to remove particulate matter, bacteria, and some soluble components in runoff before entering the underlying groundwater. The use of infiltration facilities can also assist in maintaining the predevelopment groundwater recharge conditions at the site and help to sustain local stream baseflow. Stormwater runoff that would normally be routed away from the development site is now infiltrated into the underlying soils, via the infiltration basin, thereby recharging local groundwater.

Infiltration basins are appropriate for relatively small drainage areas (5-50 acres), especially residential areas that have lower sediment and pollutant load contributions when compared to industrial or commercial developments. This method of stormwater management helps maintain levels of local groundwater, an important consideration for areas that depend on these resources. Two major disadvantages exist with infiltration methods. Infiltration designs are susceptible to failure, basically as a result of poor construction and inadequate maintenance. Secondly, infiltration practices may introduce unwanted groundwater contaminants, especially nitrogen and phosphorus, that may be detrimental to nutrient sensitive areas. Additionally, infiltration should be discouraged in close proximity to public drinking water supplies. Albeit, in most cases, properly constructed and maintained infiltration facilities can safeguard and enhance existing water quality. Eventually, the infiltration capacity of a basin will have to be restored as a result of fine sediments clogging the soil pores at the surface.

8.2 Site Suitability

(a) The maximum contributing watershed area for a single infiltration basin should be limited to 50 acres. Development sites larger than 50 acres are best served by other BMPs such as wet ponds or extended detention basins that are capable of handling sustained baseflows from the drainage area. Another option for larger sites is using infiltration trenches in upland areas (water quality improvement) and a pond/basin design (water quantity control) at the lower portion of the drainage area. This approach for many developments may be the preferred method to meet both peak discharge control and water qua] ty improvement objectives.

b) All applicable guidelines in Section 6 for general infiltration requirements must be followed.

8.3 Design and Construction Procedures

(a) The minimum volume of the infiltration basin must be equal to the water quality volume (1 inch by the area of impervious surfaces in the drainage area). The sediment pretreatment device (e.g., over-sized catch basins) should have the capacity to store the volume of expected sediment accumulation from the drainage area.

b) The maximum allowable depth of the infiltration basin is determined by the following formula:

$$D_{\sim} = f \times T_s$$

where;

D_{max} = maximum allowable basin depth (inches)
f = final infiltration rate (in/hr) from method in Section 8
T• = maximum storage time (72 hours)

For example, if the infiltration rate has been determined to be 1.5 in/hr, then $D_{\_1}$ = 1.5 x 72 hours = 108 inches or 9 feet. This is the maximum allowable depth of the basin **to ensure** that the design runoff volume will be completely exfiltrated after **72 hours** with no **standing** water **in** the basin. If site constraints such as **shallow** bedrock **or** groundwater levels are present, then the basin **depth** will have to be **adjusted** accordingly, to maintain the required minimum separation distances (see Section 6). Please note that a detailed mounding analysis may **be** needed for the site specific conditions as the above formula is **based** on unsaturated flow conditions, therefore an appropriate design based on the mounding analysis is recommended.

(c) For overall site development the entire area of the proposed infiltration basin should be roped off to prevent compaction of the underlying soils by heavy equipment. The basin should be excavated with light earth-moving equipment to prevent compaction of soils beneath the basin floor or side slopes. If heavy equipment is used, the infiltration capacity of underlying soils will be severely reduced, resulting in basin failure and costly remediation efforts. Light earth-moving equipment does not include bulldozers or standard size payloaders.

(d) Proper soil erosion and sediment control methods must be used during and after development of the site. The recommended methods are found in the latest edition of the Rhode Island Soil Erosion **And** Sediment Control Handbook.

(e) If basins are constructed in natural depressions all trees and shrubs should be removed. The entire basin should be planted with hardy grasses (e.g., Tall Fescue or Reed Canary).

(f) Trees or shrubs should not be planted on any impounding embankments (i.e., dikes or berms) or within the basin. Such plantings are generally discouraged in order to reduce the chance of failure due to root decay and subsurface disturbance. Grasses are considered the only acceptable vegetation for planting and stabilizing impounding embankments.

(g) The entire basin must be stabilized with a dense layer of grass inunediately following basin construction. This may require the addition of 4-6 inches of a loamy soil substrate to promote good vegetative growth and infiltration. The addition of loamy soil to the basin must be factored into the overall volume requirement. Turf-type tall fescues or reed canary grass are the preferred grasses because of their tolerance to a variety of environmental conditions, aesthetically pleasing form, nitrogen scavenging capabilities, and ease of maintenance.

(h) Infiltration basins should have a pretreatment device (see Section 8) incorporated into the final design with sufficient volume to contain 10 years of accumulated sediments from the contributing drainage area (see Section 3 for calculating sediment volumes). This device(s) should be located to facilitate access for maintenance.

(i) The basin floor should be graded as flat as possible (zero slope) to promote uniform ponding and exfiltration of runoff. The basin floor should be deeply tilled with a rotary tiller or disc harrow prior to seeding operations to promote infiltration in the surface layers

C) The maximum allowable slope leading to the basin floor shall be 3:1 (3 horizontal to 1 vertical) to facilitate mowing and other maintenance operations. See Figure 8.1 for an illustration of a typical infiltration basin.

(1) Inlets should discharge at the design basin floor elevation with measures to ensure non-erosive velocities of flow. Appropriate velocity dissipator devices are required at all inlets to prevent unnecessary gouging and pooling of water below the inlet. Appropriate erosion control devices are also required at all discharge (outlet) points of the basin, including the emergency spillway. These erosion prevention methods must be designed to handle the expected runoff velocities.

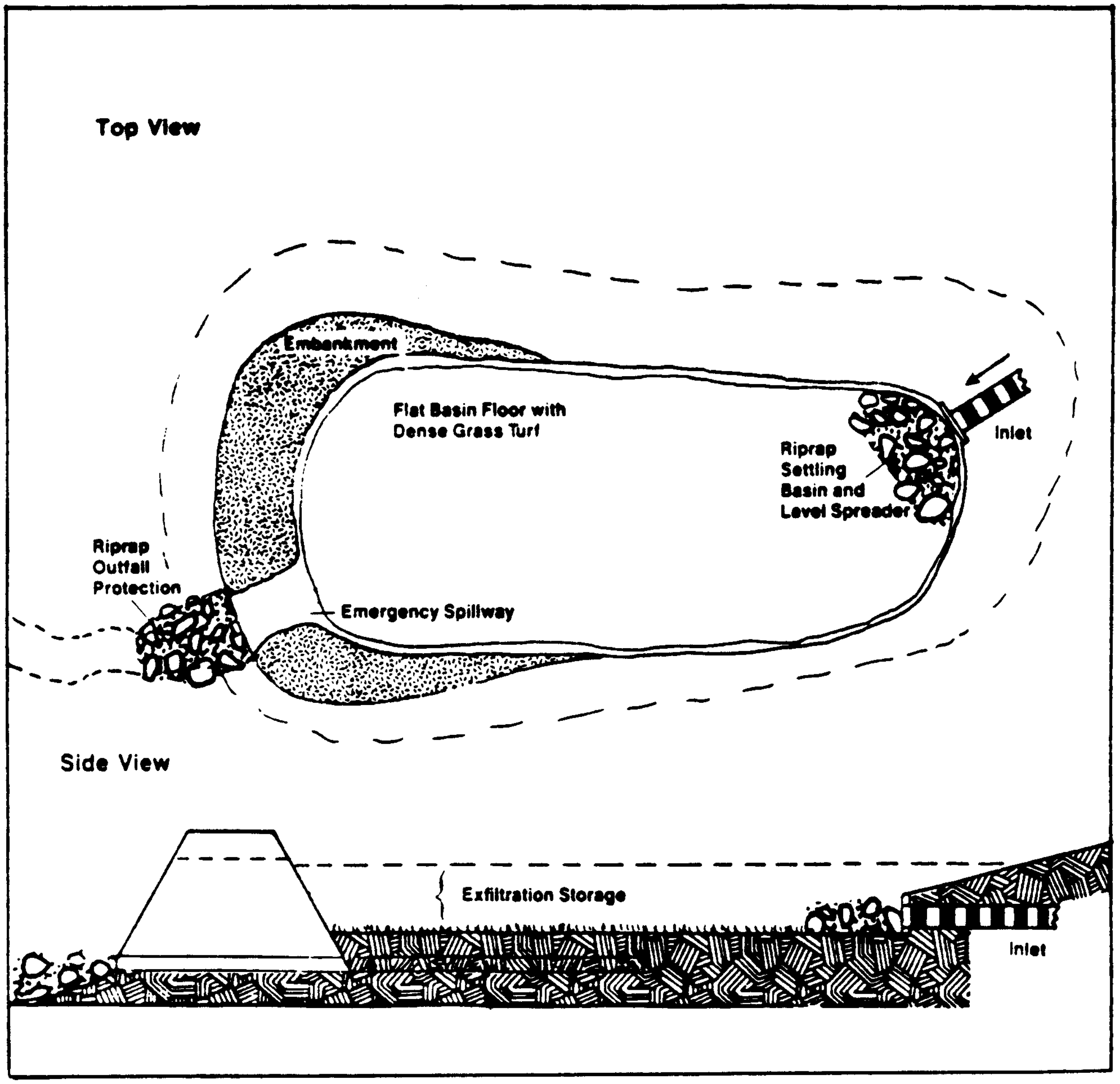
(1) All infiltration basins must have an emergency overflow capable of passing runoff without damage to the impounding structure. The recommended spillway is a weir with the invert of the weir Located at least 1 foot below the embankment. The overflow structure must provide for non-erosive flows along the spillway and channel leading away from the structure.

(m) The channel below discharge outfalls must be designed to be stable against the maximum design flow discharging from the facility.

(n) Infiltration basins should not receive runoff until the entire contributing watershed area has been stabilized with vegetation and other soil erosion and sediment control techniques. Failure to do so will result in excessive quantities of sediments to enter the basin and result in premature failure of the infiltration system.

(o) A maintenance right-of-way must be provided for access to the basin. It should be a minimum of 15 feet wide and cannot cross over any outflow channels, including the emergency spillway.

Figure 8.1 Schematic of an Infiltration Basin. (Source: Schueler, 1987)



8.4 Maintenance Requirements

(a) The structural integrity of the basin, especially any impounding structures, should be inspected on an annual basis. In addition, the inlets for the basin should also be inspected annually. Any deficiencies must be corrected immediately after observation. The basin and all structures should be inspected more often during the first year of operation, especially after large storms, to ensure proper stabilization and function.

(b) The mowing of grass in and around the basin should be done at least once per growing season, preferably after August 15 to protect ground nesting birds and other animals. More frequent mowings will be required for basins maintained as recreational or open space facilities. Trash and litter must be removed during mowing operations.

(c) Reseeding of any eroded or bare spots in or around the basin must be done immediately following examinations to prevent subsequent soil erosion. Maintaining a fUlly vegetated basin with healthy grass is paramount to a successfully operating facility.

(d) Eventually, the infiltration capacity of a basin will decrease requiring deep tilling of the basin floor every several years (5-10) to restore the original infiltration rate. Tilling should be done when there is an obvious loss of infiltration, especially when standing water is present in the basin for more than 72 hours after a rainfall event. Tilling can be accomplished with a rotary tiller or disc harrow, and in some cases the addition of organic matter or sand will assist in restoring infiltration capacity. After tilling, basin floors must be reseeded immediately to prevent erosion of the basin bottom (during appropriate growing period).

(e) The developer must abide by any municipal fencing restrictions or other requirements.

SECTION 9

INFILTRATION TRENCHES AND DRY WELLS

9.1 Introduction

An infiltration trench is excavated into the soil and filled with small clean stone. It is used to temporarily store runoff in the void space of the stone-filled reservoir and allow exfiltration of runoff into the surrounding soil. There are two basic types of trenches that are distinguished by contrasting designs. Surface-exposed trenches are open to the atmosphere, with the top layer of stones filling the trench being visible. Runoff water runs overland through a vegetated filter strip prior to entering the trench. The other type is an underground trench, whereby the trench is covered by soil and turf or perhaps pavement. Runoff water enters the trench through a series of drainage pipes and, in certain cases, an oil/water separator. All proposals with underground trench designs require a review from the DEM Groundwater Section, Underground Injection Control (UIC) Program. All commercial or industrial applicants with underground trench designs require an Order of Approval through the UIC Program. See Eigure 9.1 for a typical infiltration trench design.

Because of their thin profile, infiltration trenches have tremendous adaptability for many development sites. This type of liMP has a number of applications, including the placement around the perimeter of parking lots, along highway strips and road sides, or incorporated into a swale design for residential property (see Figure 92). Infiltration trenches can be very useful on larger sites, especially when placed in the upper reaches of the drainage area (provided the drainage area is _5 acres). Used in this manner, these trenches help reduce the overall amount of runoff from the contributing drainage area and improve the quality of runoff in the lower part of the site.

Infiltration trenches should be constructed to treat water quality only (see Section 9.3(a) below) and not used to manage flood flows. Additional runoff volumes should be directed to other conventional detention structures, on-site or further down in the watershed to a regional facility, if one is available.

One of the limiting factors of infiltration trenches is their susceptibility to premature failure due to clogging from sediments (albeit, trenches fail less often than basins). It is imperative to protect trenches before, during, and after site construction with appropriate soil erosion and sediment control techniques to ensure proper functioning of the infiltration system. System failure will require immediate repair or costly excavation and replacement of the trench.

Figure 9.1 Schematic of an Infiltration Trench. (Source: Schueler, 1987)

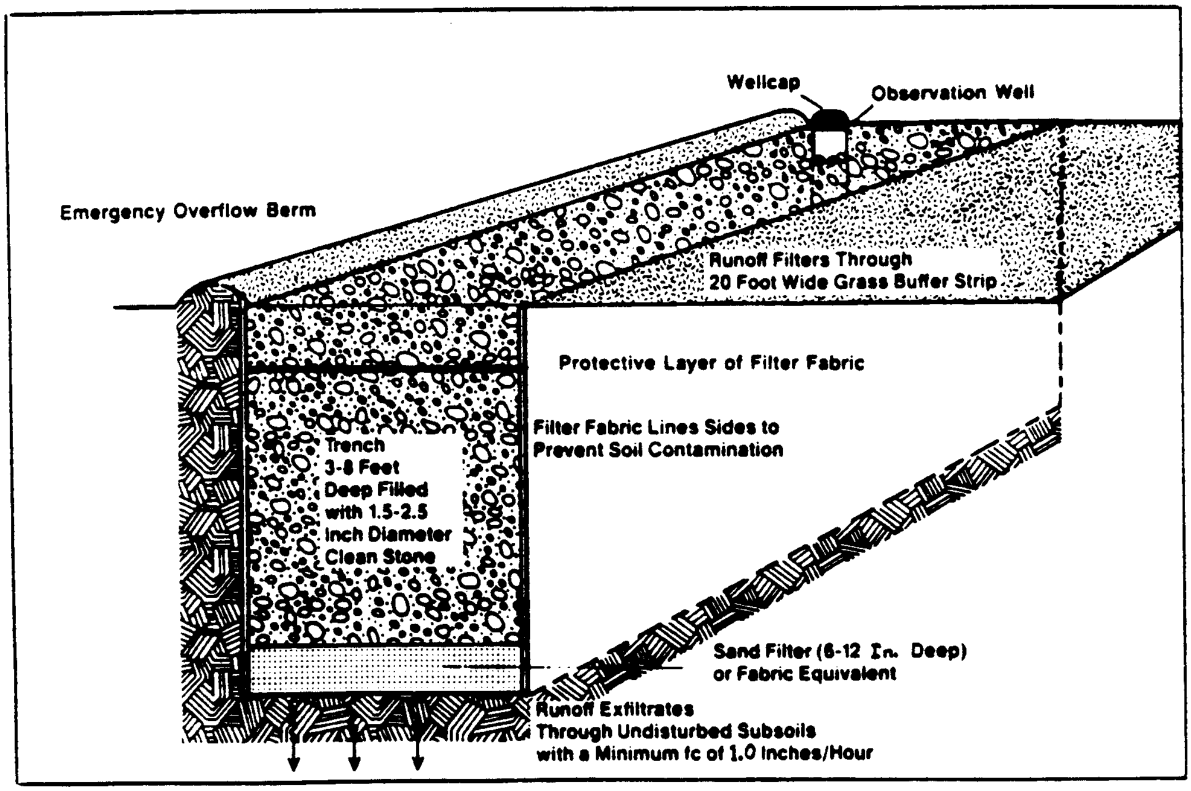
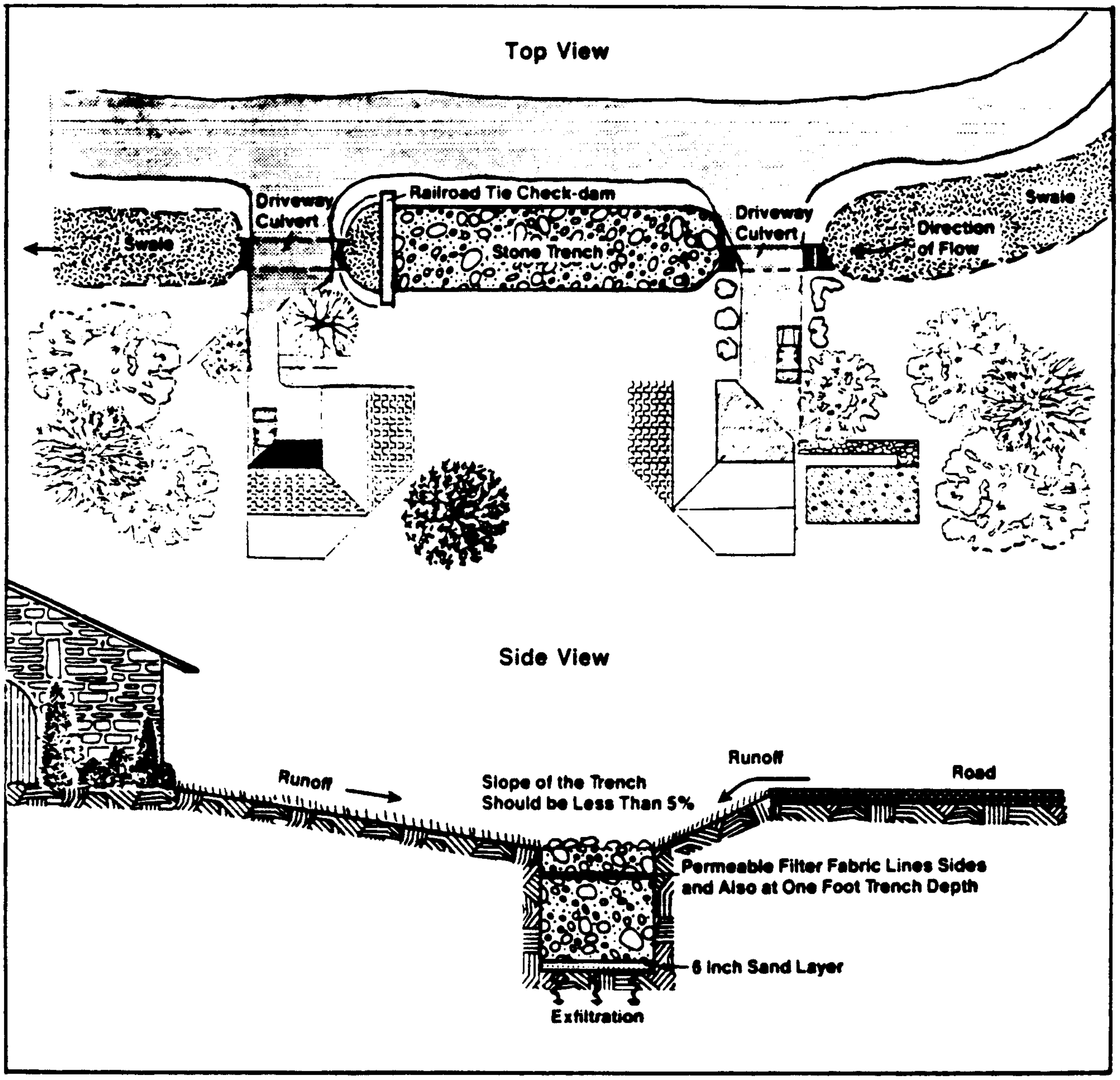


Figure 9.2 Schematic of an Infiltration Trench used in a Residential Drainage System. (Source: Schueler, 1987)



Dry welts can be useful for disposing of clean roof-top runoff and reducing the overall runoff volume from a site (see Figure 9.3). This method also assists in reducing **the** size of the primary BMP for the site and associated costs. Infiltration of roof-top runoff from commercial or industrial buildings with pollution control, heating, cooling, or venting equipment may require UIC review and approval.

9.2 Site Suitability

(a) The use of infiltration trenches as the primary BMP utilized on a site should be limited to drainage areas that are acres. Drainage areas larger than 5 acres should use other stormwater management methods capable of handling concentrated flows.

(b) All applicable guidelines for infiltration practices in Section 6 must be followed.

9.3 Design Procedures

(a) Once the suitability of a site has been established for using trenches as a method of stormwater disposal, the necessary trench size must be determined. The first step is to calculate **the** water quality (WQ) volume, which is accomplished by determining the area of impervious surfaces of the site and multiplying this figure by 1 inch.

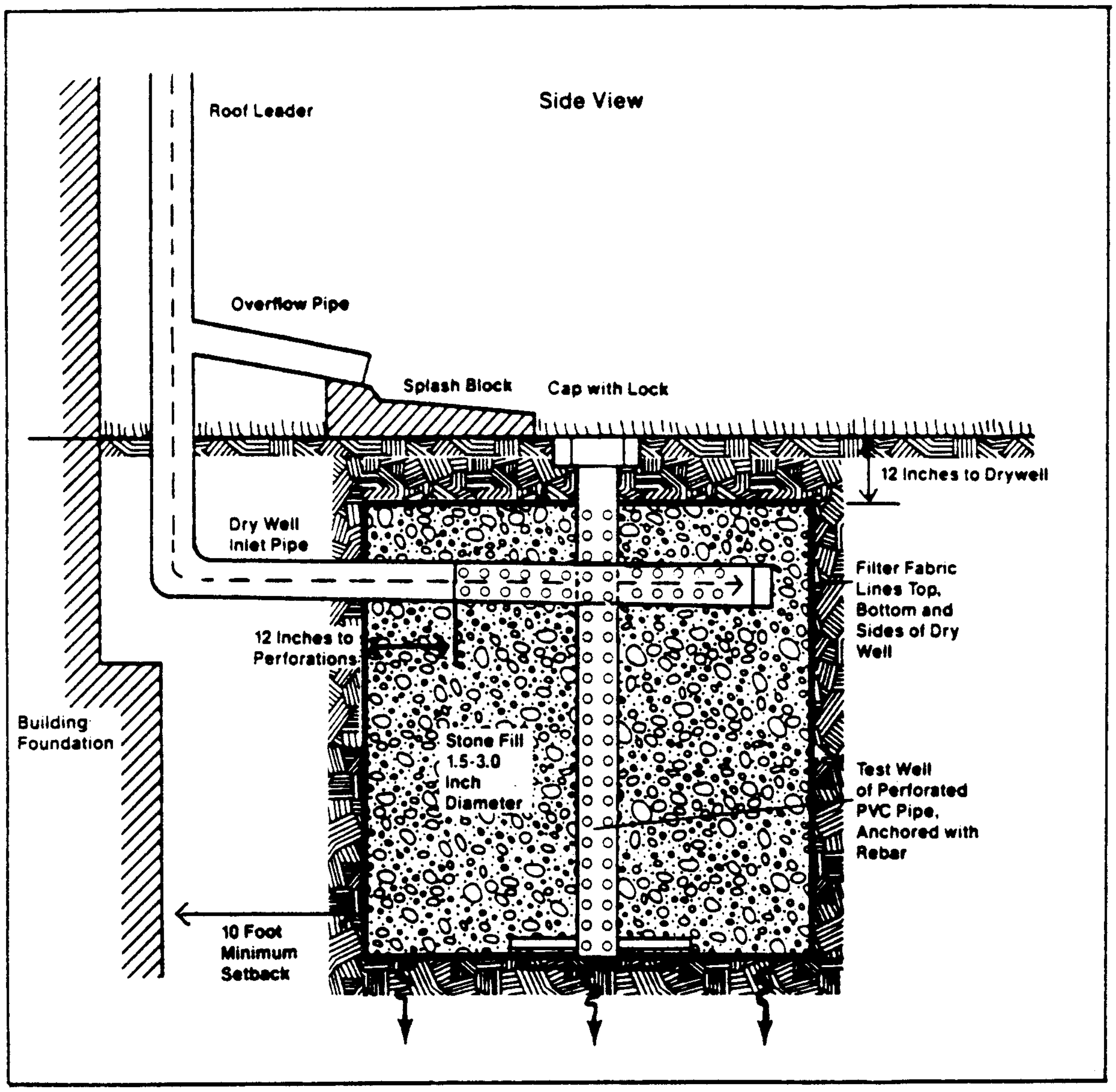
(b) Since the stones filling the trench will occupy some of the volume that otherwise would be filled by water, the trench void space must be determined. It is assumed that using stones with a diameter between 1.5 and 3.0 inches will yield a void space of approximately 30-40 percent. The required trench size which will compensate for both water quality volume and the volume occupied by the stone fill is calculated with the following formula:

Trench size = WQ volume x (1/Void space traction)

For example, consider a 4 acre residential development with 20% of the development having impervious surfaces, including roads, sidewalks, driveways, and roof tops. The area of impervious surface would be: 4 acre x .20 = 0.8 acre

The water quality volume would be determined by multiplying the area of impervious surface by I inch. This would yield: 0.8 acres x (43,560 feet^2/acre) x 1 inch x (1 footll2 inches) = 2903 cubic feet..

Figure 9.3 Schematic of a Dry Well Design. (Source: Schueler, 1987)



Finally, the void space is determined to be 35 percent and the required trench size for the 4 acre site is calculated as follows:

$$\text{Trench size (volume)} = 2903 \text{ cubic feet} \times 1/0.35 = 8294 \text{ ft}^3$$

(c) A detailed mounding analysis may be necessary during the design phase for the site specific conditions to ensure that the water quality volume is exfiltrated within 72 hours. The above trench volume formula assumes <u>unsaturated</u> flow conditions, therefore an appropriate design based on the mounding analysis is recommended.

(d) Dry wells should be designed to accommodate the volume obtained by multiplying the area of the contributing roof top by 1 inch. It may be preferable to construct two dry wells per dwelling, each one servicing one side of the roof An example of a properly constructed dry well is illustrated in Figure
10.3.

(e) All trenches and dry wells should be completely lined with an engineering filter fabric (geotextile cloth), including all sides, top, and bottom so that the cloth completely surrounds the stone reservoir. Caution must be exercised when choosing geotextile materials to ensure compatibility ~4th surrounding soil textures and application purposes. This filter fabric will prevent sediment and other debris from entering the trench and clogging the internal infiltrative surface. Surface exposed trenches should be constructed in such a manner that the top 12 inches of stone is not enclosed within the filter cloth, If an infiltration trench becomes clogged then the top 12 inches can be removed and replaced without excavating the entire trench or disturbing the filter fabric. (In some cases the top layer of filter fabric can also be clogged and may have to be cleaned or replaced). The cut width of the filter fabric should include sufficient material to include a 12 inch minimum overlap. Place the fabric roll over the trench and unroll a sufficient length to cover the side, bottom, and up across the opposite side, including the required 12 inch overlap. When overlaps are required between rolls, the upstream roll must lap a minimum of 2 feet over the downstream roll to provide a shingled effect. The overlaps ensure fabric continuity and reduces opportunities for sediment intrusion within the trench.

(f) Trenches and dry wells should be filled with 1.5-3.0 inch diameter, clean-washed stone only. Stones that are washed have minimal particulate matter, thereby reducing the chance of clogging infiltration surfaces. The void space wilt be between 30-40 percent with the specified stone diameter criterion.

(g) All trenches and dry wells should have an observation well installed to monitor long term performance of the system. These wells should be constructed of perforated 4 inch diameter PVC pipe, extend to the design bottom of the trench, and be securely capped to discourage tampering and vandalism. The observation wells can be secured in position by placing a section of rebar through a perforation in the bottom of the pipe, prior to filling the trench with stone aggregate. Monitoring water levels within the pipe at various time intervals after a rain fall event will indicate the infiltration ability and performance of the system. Obviously, if water is standing in a pipe more than 3 days after a storm event, then failure of the system has occurred and should be addressed through repair or replacement of the trench.

(h) Slopes within 100 feet of surface-exposed trenches should not exceed *5* percent. Steeper slopes will generate excessive runoff velocities and minimize treatment provided by the vegetated filter strip. Underground trenches are not feasible on sites with slopes greater than 20 percent. The bottom slope of all trenches should be as close to zero as possible.

(i) The area surrounding the proposed trench should be roped off during construction to prevent heavy equipment *from* compacting the soils. Hay bales and silt fences must be placed and maintained around the area of the trench to prevent sedimentation. Proper soil erosion and sediment controls must be followed through all phases of construction to keep sediments away from the trench area. Actual construction of any trench can not be undertaken until the entire site has been completely stabilized with vegetation or other soil erosion prevention techniques. All applicable soil erosion guidelines in the most recent edition of the Rhode Island Soil Erosion and Sediment Control Handbook must be followed.

(j) The establishment of vegetated filter strips (see Section 10) surrounding surface trenches should preferably be accomplished by sodding. If hydroseeding is used, a properly installed and maintained silt fence must be placed between the trench and the filter strip until the filter strip becomes fully established.

(k) All underground trench designs should provide for pretreatment of runoff prior to entering the trench. In some cases this may require the installation of an oil/water separator. The design requirements for oil/water separators are listed in Section 7.

9.4 Maintenance

(a) Trenches should be inspected for proper functioning often during the first few months and annually thereafter. Drainage within the trench can be examined by observing water levels in the observation well and calculating drainage rates.

(b) The filter strip area surrounding surface trenches should be inspected during mowing operations and any bare spots must be reseeded or re-sodded to maintain the integrity of the entire filter strip. Mowing should be conducted at least twice during the growing season to prevent unwanted woody growth. Mowers should be equipped with baggers or at least direct clippings away from the trench to prevent clogging.

(c) Trees adjacent to the trench should be pruned so that the “drip line” of the tree does not overlie the trench. Newly established trees (seedlings) in the vicinity of the trench must be removed to prevent roots from intruding into the trench and causing damage.

(d) Oil/water separators should be inspected at least semi-annually to ensure proper functioning. Sediments should be removed when 10 percent of the available capacity is depleted. All inlets and outlets for these systems must be inspected semi-annually for clogging debris.

SECTION 10

VEGETATEI) FILTER STRIPS

0.1 Introduction

A vegetated filter strip is an undisturbed densely-vegetated area contiguous with a developed area. These filter strips are most often located between a water resource and the developed portion of a site (see Figure 10.1). Filter strips can be composed of an undisturbed forested area or created from disturbed land by proper seeding and plantings. The most effective pollutant removal filter strip is composed of dense grass vegetation that is properly maintained. Filter strips serve to improve runoff water quality, add or maintain wildlife habitat, and provide a screening effect for home owners. This type of BMP is best suited for complementing other structural methods utilized on-site for stormwater management.

From a water quality standpoint filter strips are similar to grassed swales, except that they are designed to receive runoff as overland sheet flow. Channelization of runoff within the filter strip significantly reduces the amount of infiltration and subsequent pollutant removal. Level spreaders are structural devices used to capture and evenly distribute runoff to the filter strip while reducing the potential for channelization and maximizing treatment efficiency. It is required that drainage to all filter strips have a level spreading device incorporated into the design. Caution must be used when installing level spreaders to ensure long-term even flow and distribution of runoff to the filter strip.

The use of a filter strip as the sole water quality BMP is permissible only when no other BMP method, as described in this manual, can be utilized because of site constraints. This has to be clearly demonstrated by the applicant and approved by the permitting agency. Home lawns cannot be considered part of a buffer strip because these areas receive extensive pedestrian traffic and are intensively groomed which result in very short grass height. Low volume pedestrian pathways are allowed to be constructed through a buffer strip, provided they are no greater than 4 feet wide and take a winding course to reduce the potential for channelized runoff flow. Pesticides should not be applied in these areas, although minimal fertilizer use is acceptable to help seeded areas become more quickly established. Incorporating organic material, such as mulch, into the topsoil is encouraged to promote better filter strip performance. Soils with a high content of organic material will attenuate greater amounts of pollutants from stormwater runoff.

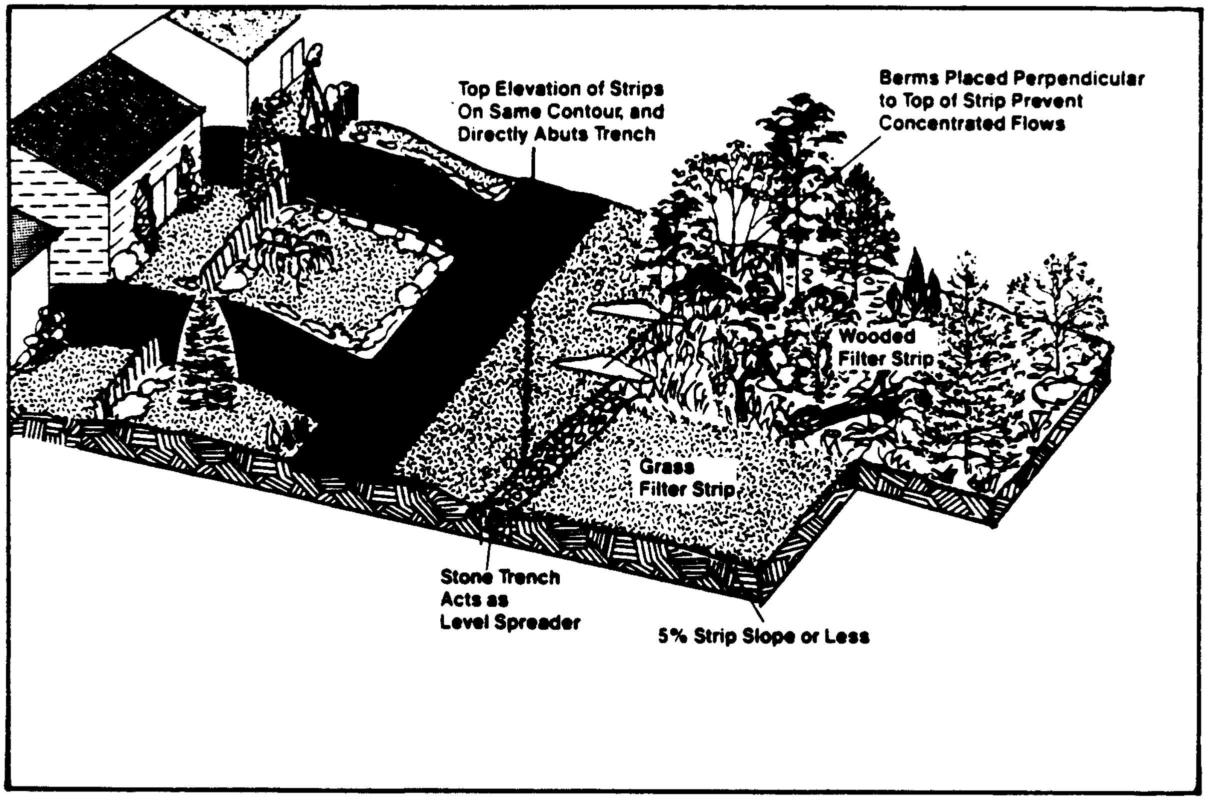
10 2 Site Suitability

(a) Individual filter strips should only serve contributing areas less than S acres to reduce the potential for concentrated and erosive stormwater flows. Sites larger than 5 acres would be required to use other BMPs in conjunction with a filter strip.

(b) Filter strips should be located on slopes of 5 percent or less to enhance filtering and infiltration of stormwater runoff. Steeper slopes will generate excessive runoff velocities and cause channelized flow and erosion within the buffer.

(c) Filter strips should have topsoil composed of loamy sands, sandy barns, loam, or silt loam. Other soils with higher percentages of finer materials (e.g., silty clay loam or

Figure 10.1 Schematic of a Vegetated Filter Strip. (Source: Schueler, 1987)



sandy clay) are poorly suited for filter strips due to very slow infiltration rates and therefore are not permissible. Therefore, other methods for water quality improvement must be considered.

(d) Upland areas regulated as freshwater wetlands such as river banks and those areas of land within 50 feet of the edge of any swamp, marsh, pond, or bog ***may*** be included as part of a required filter strip width. For example, if a project area contains a swamp, marsh, pond, or bog with an adjacent regulated area of 50 feet and it has been determined that a 90 foot filter strip will meet the stormwater performance standards, then the total distance from the outer edge of the filter strip to the swamp, marsh, pond, or bog could be 90 feet. However, the limit of disturbance may be restricted to those portions of the site outside of the regulated area.

10.3 Design Procedures

(a) The filter strip must abut the entire length of the contributing area to ensure that runoff from all portions of the site are treated.

(b) The top edge of the filter strip must follow the same elevational contour line to eliminate concentrated flows and "short-circuiting" through the buffer zone.

(c) A level spreader device must be utilized along the entire top edge of the filter strip. This device can be a shallow stone-filled trench that evenly distributes the runoff across the entire length of the filter strip. Other devices may be used to achieve an even distribution of runoff, provided the applicant can prove their effectiveness and the design is approved by the permitting agency.

(d) The following steps will assist in determining the required filter strip width necessary to meet the stormwater performance standard:

(1) Determine the amount of all impervious surfaces (square feet) of the contributing area from the site plans including all roads, driveways, and roof tops.

(2) Determine the appropriate buffer sizing factor from Table 10.1 based on hydrologic soil group in proposed filter strip location.

(3) Multiply the impervious area by the number obtained from Table 10.1. The calculation provides the area required for the filter strip.

(4) Finally, divide the filter strip area obtained in step 3 above by the site boundary length to determine required buffer width.

Table 10.1
Buffer Sizing
Factors for
Hydrologic Soil
Groups. (Source:
Palmstrom,

1991)

Hydrologic Soil Group	Buffer Sizing Factor
A	0.08
B	0.12
C	0.21

(e) The minimum filter strip width shall be 25 feet. The exception will be a 20 foot minimum where filter strips are used as pretreatment for infiltration trenches.

(f) Filter strips, or areas proposed as such, must be protected by proper soil erosion and sediment control techniques (e.g., hay bales and silt fences) during all phases of construction. These measures must be properly maintained until final site stabilization and subsequent removal of all trapped sediments has occurred.

10.4 Maintenance

(a) Filter strips should be inspected at least quarterly during the first year of operation and semiannually thereafter. Evidence of erosion and concentrated flows within the buffer must be corrected immediately. Eroded spots must be reseeded and mulched to enhance a vigorous growth and prevent future erosion problems.

(b) Procedures for soil preparation and seeding should be done in accordance with the most recent version of the Permanent Vegetative Cover section in Chapter 4 of the RI Soil Erosion and Sediment Control Handbook.

(c) The bulk of accumulated sediments will be trapped at the top of the filter strip. These deposited sediments should be removed manually at least once per year or when accumulating sediments cause a change in the grade elevation. Reseeding may be necessary to repair areas damaged during the sediment removal process.

(d) Grass filter strips should be mowed only once per year, leaving vegetation a minimum of 4 inches in height. Mowing operations are to be conducted during the growing season, but preferably after mid August. This management technique maintains a tall vigorous growth and protects the young of ground nesting animals.

Natural Buffers

Natural buffer areas can be one of the most important components within a development scheme, not only from a stormwater management perspective, but they can also reduce noise pollution and provide valuable wildlife habitat and scenic values. New development tends to fragment large tracts of undisturbed areas and displace plant and animal species, therefore it is essential to maintain these buffers in order to minimize impacts. Properly sized and maintained buffers or "vegetated filter strips" will improve water quality by: trapping sediments and other settleable pollutants; preventing erosion; allowing for plant uptake of soluble components (e.g., phosphorus and nitrogen); assisting in denitrification of nitrate-nitrogen; and facilitating the infiltration of runoff water.

Vegetated filter strips can also be designed and constructed as best management practices, whereby an area can be planted with a hardy grass (planted as a meadow) and maintained with 1 or 2 mowings per growing season. These engineered filter strips can be effective at reducing stormwater runoff impacts from a site. However, they do require a higher degree of maintenance and therefore, natural buffers are preferred. Naturally occurring buffer zones must remain unaltered, both during and after construction and site stabilization. Buffer zones adjacent to water bodies (both fresh water and coastal) are protected under Rhode Island state law and cannot be altered without a state agency (DEM or CRMC) permit.

SECTION 11

GRASSED SWALES

11.1 Introduction

A swale can be defined as a grassed waterway used to convey stormwater runoff from a development site to a control structure (e.g., detention basin, wet pond, infiltration basin, etc.). Typical applications include single-family residential areas and highway medians. These waterways are generally less expensive than traditional curb and gutter methods, and at the same time provide some water quality benefits. Swales should not be used as the sole water quality improvement BMP as they do not achieve high pollutant removal rates. Grassed swales have a limited ability to handle large volume storms and concentrated flows. Therefore, they must be used in areas where expected runoff velocities are less than 5 feet per second to reduce the potential for gullying and erosion within the swale. Grassed swales should be used in combination with other best management practices to reduce peak flow rates, mitigate potential flooding, and improve water quality.

Swales help to control runoff volumes and peak discharge rates by two mechanisms. First, runoff volumes are reduced slightly by limited infiltration within the swale. Secondly, the grass offers resistance to runoff flowing through the swale. This slows the velocity while increasing the time of concentration, thereby reducing the peak discharge rate. It is through the infiltration and sediment deposition processes that some pollutants are removed from stormwater runoff. As runoff velocities are decreased, some sediments will be deposited within the swale and thus effectively removed from the final downstream sediment load. The infiltration process will transport some metals and other pollutants (e.g., nitrogen and phosphorus) into the soil where they become bound to the soil complex or taken up by vegetation.

Swales can be made more effective if a check-dam is added to the design (see Figure 11.1). This feature provides temporary storage upstream of the check-dam, increasing the volume of infiltrated runoff, and improving water quality compared to swales without check-dams. Grassed swales should be incorporated into the site development plan to the greatest extent possible. Design guidance for the construction of swales can be found in the Grassed Waterways section (Chapter 6) of the most recent edition of the <u>RI Soil Erosion and Sediment Control Handbook</u>.

11.2 Site suitability

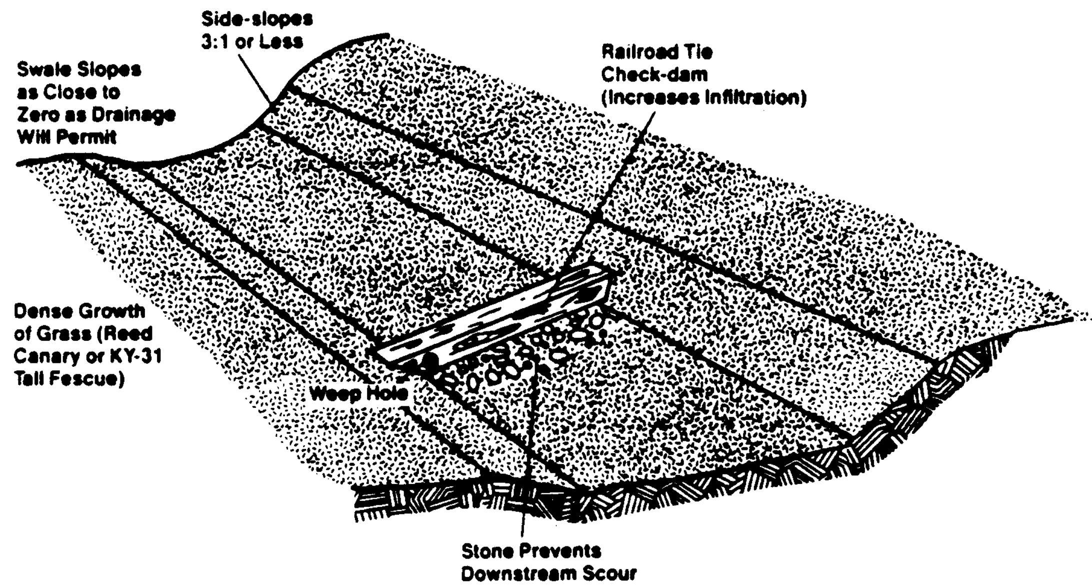
(a) The soils on which grassed swales are proposed should have an infiltration rate of at least 0.5 inches per hour.

(b) There should be a minimum separation distance of 2 feet between the design bottom of the swale and the seasonal high water table elevation to minimize potential pollutant intrusion to groundwater. Seasonal high water table elevations should be determined using methods described in Section 6 of this manual.

(c) Swales should not be closer than 100 feet to any public or private well to prevent the potential for drinking water contamination.

(d) The minimum separation distance between swales and any component of an individual sewage disposal system should be 50 feet (subject to SD 3.00 of the DEM ISDS regulations).

Figure 11.1 Schematic of a Grassed Swale. (Source: Schueler, 1987)



(e) The bottom of the swale should have slopes as close to zero as drainage will allow to prevent excessive velocities and erosion within the swale.

11.3 Design procedures

(a) Swales should be designed to handle the proposed peak discharge rates from the development. In most circumstances the maximum design discharge rates will be based on the 25-yr and in some cases the 100-yr storm events.

(b) Swales should be designed using Manning's formula as follows (see Dunne and Leopold, 1978 for additional information on this formula):

flow rate (ft./sec.) = Q = (1.49/n)(A)(R)~"(S)"~

where,

ii = roughness coefficient

R = hydraulic radius (ft)
S = hydraulic gradient (slope in ft/ft)
A = cross-sectional area (ft^2)

(c) Side slopes of the swale should be 3:1 (horizontal:vertical) or flatter.

(d) The overall slope along the length of the swale should not exceed 5 percent.

(e) Outlet protection measures must be used at any discharge points from the swale. Stone rip-rap is one of the more popular methods used to reduce potential erosion at discharge outlets. The design and diameter of the rip-rap must be appropriate for the expected discharge energy to prevent dislodging of installed rip-rap.

(f) The addition of check-dams to the swale (see Figure 11.1) is encouraged to promote better efficiency in controlling peak discharge rates and improving water quality. The maximum allowable check-dam depth is determined using the following formula:

Maximum depth = = f(T~)

where,

f = final infiltration rate at the design bottom of the swale (in/hr)

= maximum allowable ponding time = 24 hours

(g) The maximum permissible velocity should be consistent with the grassed waterway design criteria contained in the most recent edition of the RI Soil Erosion and Sediment Control Handbook.

(h) The swale must have a dense cover of water tolerant and erosion resistant grass established immediately following the construction phase. Reed Canary grass (Phalaris arundinacep) is ideal for wet conditions while seed mixtures containing fescues are more tolerant of drier conditions. Additionally, the guidelines for soil preparation and seeding found in the Permanent Vegetative Cover Section of the RI Soil Erosion and Sediment Control Handbook (1989) are recommended for guidance.

11.4 Maintenance

(a) Swales should be mowed at least once per growing season to prevent establishment of woody growth and other undesirable plants that inhibit proper performance. Grass vegetation should not be cut shorter than 4 inches. It is important not to engage in excessive mowing operations, as this keeps the grass too short and decreases the efficiency of the vegetation to reduce runoff borne sediments and velocities.

(b) Bare spots and eroded areas within the swale must be reseeded immediately following observations to prevent subsequent failure of the system.

(c) Swales should be inspected on a semi-annual basis. All trash and other litter must be removed during inspections.

(d) Sediments should be removed at least once per year or more frequently if sediments are over topping check-dams. Accumulated sediments must be removed manually to prevent damage to the swale. Reseeding may be necessary after sediment removal operations, especially if excessive damage is done to vegetation.

SECTION 12

GENERAL MAINTENANCE REQUIREMENTS **FOR BMPs**

12.1 Introduction

The key to successful long-term operation of stormwater facilities is proper maintenance procedures on a regularly scheduled basis. The most carefully designed and constructed stormwater BMP will be subject to eventual failure in the event of poor or inadequate maintenance. Failure of a BMP results in costly repairs or replacement of a system, therefore it is imperative that the responsible party(ies) conduct maintenance as provided on the final site development plans. Very often, maintenance of BMPs is incorporated into the state and local approval process for land development. Accordingly, the following recommendations should be adhered to where applicable.

12.2 Requirements

(a) A maintenance schedule for each type of BMP must be included in the application package and on the final site plans. These schedules should list the frequency and type of maintenance operations necessary along with the legally responsible party's(ies') name, address, and telephone number. If the stormwater drainage system is to be deeded to the local municipality the applicant must obtain a letter from the municipality acknowledging maintenance responsibility and intent of ownership.

(b) An area should be set aside within the development site for the purpose of sediment disposal (where applicable). The disposal area should be large enough to handle the volume of two clean-out cycles. The site can also serve as open space and recreation areas.

(c) Proper erosion and sediment control practices must be implemented during all phases of construction and until the site is satisfactorily stabilized. These plans must be printed on the final site plans submitted for approval. All control practices should be in accordance with the most recent edition of the RI Soil Erosion and Sediment Control Handbook.

(d) Grasses (e.g., conservation seed mixture) must be planted around and within basins immediately following construction to stabilize the slopes and prevent erosion. Trees and shrubs should not be planted on any impounding embankments, to prevent potential subsurface disturbance and possible failure of the structure.

(e) Side-slopes, embankments, and the upper stage of basins should be mowed at least once per growing season, to prevent unwanted woody growth. Mowings can be more frequent in residential areas if a more groomed appearance is desired, however if a stormwater facility is managed for wildlife habitat mowings should be conducted after mid August to prevent mortality to ground nesting birds and animals.

(f) All trash and litter and other debris shall be removed from any stormwater facility including inlet and outlet structures. Maintenance of this type improves the physical appearance of the facility and prevents blockage of inlet/outlet structures, thereby averting failure of the structure. This must be accomplished at least twice per year, preferably spring and fall

(g) Sediments should be removed from any basin immediately following site stabilization and thereafter in accordance with the specific maintenance plan. Accumulated sediments may have to be removed more frequently if the sediment storage capacity of the forebay or sediment storage area is within the last 10 percent of it's available capacity. Sediment removal within a basin should restore the original capacity and design depth.

(h) If blockage of a basin outlet structure occurs it may be necessary to dewater the pond for access to the blockage. The dewatering flow must be adequately filtered prior to discharge into a receiving water body to remove suspended solids.

(i) Pools of stagnant water in detention basins indicate failure due to erosion and scouring of the basin bottom, particularly near an inlet device. This deficiency should be corrected immediately to prevent a nuisance habitat for insects, especially mosquitoes.

(j) All outlet structures and outflow channels should be inspected annually. Furthermore, extended detention devices should be inspected at least twice per year. Inspections should be accomplished several times during the first six months of operation, especially after rainfall events to check for clogging or, conversely, too rapid of a release.

(k) The grassed areas of any basin should be inspected at least twice per year to check for erosion problems. Problem areas must be reseeded immediately to stabilize exposed soils, thereby preventing erosion and potential clogging of outflow devices.

(I) Inspections of all catch basins on-site should occur on an annual basis to check for debris removal (sediment and hydrocarbons) and structural integrity or damage. Such deficiencies must be corrected immediately.

(m) Repairs or replacement of inlet/outlet structures, rip-rap channels, fences, or other elements of the facility should be done within 30 days of deficiency reports. If an emergency situation is imminent then repair/replacement must be done immediately to avert failure or danger to nearby residents.

SECTION 13

SITE PLAN REQUIREMENTS

13.1 Introduction

Site plans are essential for assessing potential impacts from the proposed development and compliance with current state and local regulations. These plans illustrate all the proposed stormwater structures and assist the regulatory agencies in reviewing the adequacy and function of designs. Site plans must be stamped, dated, and signed by a professional licensed to practice in the State of Rhode Island. This includes Professional Land Surveyors, Registered Landscape Architects and Professional Engineers. However, plans detailing many structural best management practices and their components such as outlet structures, detention berms, etc., must be stamped by a Professional Engineer certifying the design and function of these stormwater structures.

It is imperative that applicants submit complete and accurate site plans along with any supporting calculations for this review process. Incomplete plans only delay the review process, which in turn delays the applicant from obtaining required permits and construction start-up. The following information is provided as guidance for applicants to include on site plans. However, various regulatory programs may have differing requirements that are more or less specific depending on the proposed project. Therefore, applicants are advised to seek guidance from the state or local permitting authority to ensure minimum site plan requirements are adequately addressed.

13.2 Existing Conditions Site Map

The existing conditions site map is useful for reviewing the physical features present at the proposed development site prior to any alteration from land disturbance or construction. This map of predevelopment conditions should at minimum include the information listed below. Additionally, this map should have a scale no smaller than 1 inch = 100 feet with contour intervals no greater than 5 feet. Larger map scales providing greater detail will be acceptable. Individual sheets must not exceed 24 inches by 36 inches.

(1) North arrow with scale.

(2) Existing topography of the site.

(3) Subwatersheds must be clearly delineated and numbered for reference. Within each subwatershed the following information must be clearly noted: Area in acres, runoff curve number, soil types, hydrologic class, and hydrologic condition.

(4) The stormwater discharge location for each subwatershed must be identified and labeled with peak discharge rates and volumes for the required design storms.

(5) Location of steep slopes, bedrock outcrops, or other significant site constraints.

(6) The applicants property lines and boundaries of proposed development with bearings and distances.

(7) Abutting property owners and their respective boundaries must be clearly shown along with nearby utility pole numbers and adjacent streets and intersections to facilitate identification of the proposed development.

(8) All perennial and intermittent streams, wetland boundaries, surface water bodies, and areas subject to storm flows or flooding must be indicated. In addition, all coastal features (as identified in the CRMP), should be delineated where applicable.

(9) The 100-year flood plain boundary with 100-year flood elevations and floodway must be clearly identified consistent with the most recent Federal Emergency Management Agency maps. This may include identifying any applicable flood velocity zones.

(10) The location of existing on-site stormwater structures.

(11) The location and types of easements.

(12) The seasonal high groundwater table in the location of proposed stormwater structures (e.g., detention basins, infiltration trenches, vegetated swales, etc.) as established in accordance with the procedures described in Section 6 of this manual.

(13) Location of any required investigative soil pits or test wells.

(14) The delineation of major soil types in the vicinity of the proposed development as identified by the RI Soil Survey or qualified professional.

(15) Location of private and public water supply wells within 100 feet.

(16) Location of existing ISDSs abutting to and within the development site.

(17) Vegetation cover type including outline of woodland cover.

(18) Existing open space.

(19) Any landmarks, stone walls, fences, etc.

13.3 Proposed Final Site Map

The final site map must have all information necessary to evaluate the proposed project after the final construction **phase is** completed. This map must be at the same scale as the existing conditions site plan map(s) and include the following information.

(1) North arrow with scale.

(2) Subwatersheds must be clearly delineated and numbered for reference. Within each subwatershed the following information must be clearly noted: Area in acres, runoff curve number, soil types, hydrologic class, and hydrologic condition.

(3) Location of proposed structures and individual lots. These lots must be numbered for reference.

(4) Delineation of Individual Sewage Disposal Systems, public and private water supply wells, utility lines, and sub-drains.

(5) Location of all existing and proposed roads, driveways, parking lots, and other impervious surfaces. The total area of all impervious surfaces within each subwatershed must be clearly marked and labeled within the subwatershed boundary.

(6) All new stormwater structures (BMPs), collection and conveyance systems, and remaining portions of existing systems including points of discharge shall be clearly identified.

(7) The peak discharge rate and volume of stormwater flow shall be labeled where stormwater enters and exits all BMPs. Additionally, the final discharge points labeled with peak discharge rates and volumes of stormwater flow must be shown for all subwatersheds.

(8) All water channels or areas subject to storm flows into to wetlands, shoreline and coastal features, and tidal waters must be clearly identified whether on-site or in abutting off-site locations.

(9) Design details of all specified stormwater structures (e.g., basins, trenches, etc.) including inlet and outlet structures.

(10) Limits of vegetation clearing and overall site disturbance including delineations of lawns, open space, etc.

(11) The final elevational grade of the proposed development.

(12) Easements are required for installation and access of all stormwater management devices. These must be clearly identified on final plans.

(13) Complete soil erosion and sediment control plans to be implemented in all construction phases along with final site stabilization plans.

(14) Maintenance schedules for all stormwater structures as specified in Section 12 of this manual.

13.4 Calculations for Site Plans

In addition to the information required for site plans the following information must also be included with the application, where applicable.

(1) The area of each subbasin as identified on final site plans.

(2) The area of impervious surfaces (including all roads, driveways, roof tops, sidewalks, etc.) for each subbasin as identified in 13.50) above.

(3) Weighted curve numbers, (CN) as determined by the SCS TR-55 method, for the pervious surfaces within each subbasin as identified in 13.50) above.

(4) Invert elevations for all applicable BMPs. In addition, the elevations for

permanent and/or flood pool stages, including peak discharge rates for each stage, within all basins are required.

(5) The total volume capacity for all flood control and water quality BMPs (e.g, infiltration basins, detention basins, wet ponds, etc.). Volumes must be segregated into permanent and flood pool stage volumes where applicable. Furthermore, the volumes of all sediment storage (basins, forebays, etc.) areas must also be shown.

(6) Predevelopment and postdevelopment peak discharge rates and runoff volumes for the 2-year, 25-year, and 100-year frequency storm events for each subwatershed. The water quality volume must also be calculated for each subwatershed. All relevant variables such as curve numbers and time of concentration, along with the supporting computations and worksheets must be included.

13.5 Narrative Description

As part of the Stormwater Management Plan, a narrative description should be prepared by the applicant to provide the following information: a brief description of the proposed project; potential water quality and/or hydrologic impacts of the proposed project on surface and/or groundwater resources, existing infrastructure, and/or adjacent properties; and proposed measures or practices to mitigate potential impacts. All affected wetlands, surface water and groundwater resources, and any significant site constraints affecting the selection of stormwater management practices must be identified.

The following outline is provided as guidance for preparing a narrative description for the Stormwater Management Plan. Depending on the size and scope of the proposed project, the amount of information required by the permitting agency may vary, therefore it is advised to consult the appropriate permitting agency for specific requirements.

I. Site description - general topography, soil types, current vegetative composition and relative abundance, identification of major resources (e.g., wetlands, groundwater, surfacewaters, etc.) name of receiving water(s).

2. Site input data - watershed characteristics, area of all impervious surfaces, total area of the site, annual mean rainfall, runoff coefficients, curve numbers for various land uses, peak discharge rates.

3. Pollutant loading forecast - predevelopment and postdevelopment pollutant mass loadings to demonstrate the removal rates of individual or combined BMPs.

4. Best ManaEement Practices - identify the type of BMP and justification for selection, including any deviation from the *RI Storm water Design and Installation Standards Manual* and the potential effect on pollutant removal efficiency.

5. Technical feasibility - of BMPs including sizing, location, hydraulic and environmental impacts. Alternatives which were considered but determined not to be feasible should also be discussed.

SECTION 14

CALCULATING POLLUTANT LOADINGS

14.1 Introduction

It may be necessary to calculate potential stormwater pollutant loadings for projects proposed for sensitive resource areas, or where an elevated concern for water quality exists. When such an analysis is required of the applicant, the Simple Method (Schueler, 1987) can be used to demonstrate urban stormwater pollutant loadings. This method is easy to use and will provide the applicant and the review agency an estimate of pollutant loadings for an evaluation of potential effects on receiving waters. For a more detailed description of this method see Schueler's book Cpntrollin2 Urban Runoff: A practical manual for planning and designing urban BMPs. Table 14.1 provides concentrations for nutrients and toxic metals of concern. There may be an interest in calculating the loading rates of other pollutants not listed in this table. If this is necessary, all that is required to use the method below is the concentration of the pollutant in milligrams per liter (mg/L), based on the land use category. Other pollutant concentrations must be documented by scientific studies and referenced by the applicant.

The methods outlined in this section, including those tailored to groundwater scenarios, are most often applied to calculating loadings to surface water bodies. Other pollutant loading methods may be acceptable, provided the applicant submits the methodology and data used along with the reasoning for the method used. All information supplied by the applicant will be reviewed by the permitting agency to determine the relevance of the model to the situation.

14.2 Recommended Method

Stormwater pollutant export (L, in pounds) from a development site can be determined by solving the following equation:

(Eq 1.) $\boldsymbol{L} = [(P)(Pj)(Rv)/12](C)(A)(2.72)$

where, P = rainfall depth (inches)

Pj = rainfall correction factor

Rv = runoff coefficient expressing the fraction of rainfall converted to runoff

C = flow-weighted mean concentration of the pollutant in urban runoff (mg/L)

A = contributing drainage area of development site (acres)

12, 2.72 are unit conversion factors

Table 14.1 Pollutant Concentration Values for Differing Land Use Categories.

POLLUTANT (mg/L)	LAND USE CATEGORY					
	Resid.[a]	Comm.[a]	Indus.[a]	Urban Highway[b]	Rural Highway[b]	Undev.[c]
Total Phosphorus	0.620	0.290	0.420	0.491	0.209	0.061
Total Nitrogen	2.030	2.300	2.530	3.180	1.737	1.355
Copper	0.056	0.050	0.032	0.066	0.029	-
Lead	0.293	0.203	0.115	0.491	0.105	0.020
Zinc	0.254	0.418	1.063	0.404	0.105	0.081
TSS	228.0	169.0	108.0	174.2	53.5	-
BOD	13.0	14.0	10.0	-	-	-
COD	102.0	84.0	62.0	139.8	64.0	-

[a] - Source: Whalen and Cullum, 1989

[b] - Source: USDOT, 1990 (urban highway > 30,000 vehicles/day and rural highway < 30,000 vehicles/day)

[c] - Source: Oakland et al., 1983 (copper data is suspect and atypical, therefore not reported)

Note: Resid. = residential, Comm. = commercial, Indus. = industrial, and Undev. = undeveloped
TSS = Total Suspended Solids, BOD = Biological Oxygen Demand, and COD = Chemical Oxygen Demand

P (depth of rainfall)

The value of P selected depends on the time interval over which loading estimates are necessary. Appropriate annual rainfall values for a site specific location can be interpolated from Figure 14.1 or obtained from local U.S. Weather Service data. If a load estimate is desired for a specific design storm (e.g., 10-year 24-hour storm) then the user can supply the relevant value of P derived from local U.S. Weather Service Data. All rainfall data used in the analysis must be applicable to site location and referenced for review.

Eijcorrection factor)

Use a value of 0.9 for Pj. This represents the percentage of annual rainfall that produce runoff. When solving the equation for individual storms a value of 1.0 should be used for Pj.

Rv (runoff coefficient)

Rv is the measure of site response to rainfall events, and is calculated as:

(Eq 2.) $Rv = rip$

where, r = storm runoff (inches)
p = storm rainfall (inches)

The Rv for a site depends on soil type, topography, and vegetative cover. However, the primary influence on Rv is the degree of watershed imperviousness. The following equation has been empirically derived from the Nationwide Urban Runoff Program studies (USEPA,l983), and is used to establish a value for Rv.

(Eq 3.) $Rv = 0.05 + 0.009(1)$

where, I = the percent of site imperviousness

A value for I can be calculated by summing the areas of a impervious surfaces (e.g., buildings, driveways, roads, parking lots, sidewalks, etc.) and dividing this area by the total contributing drainage area. If more than one land use is present at the site divide the impervious portion of each land use by its' respective total area.

A (drainage area)

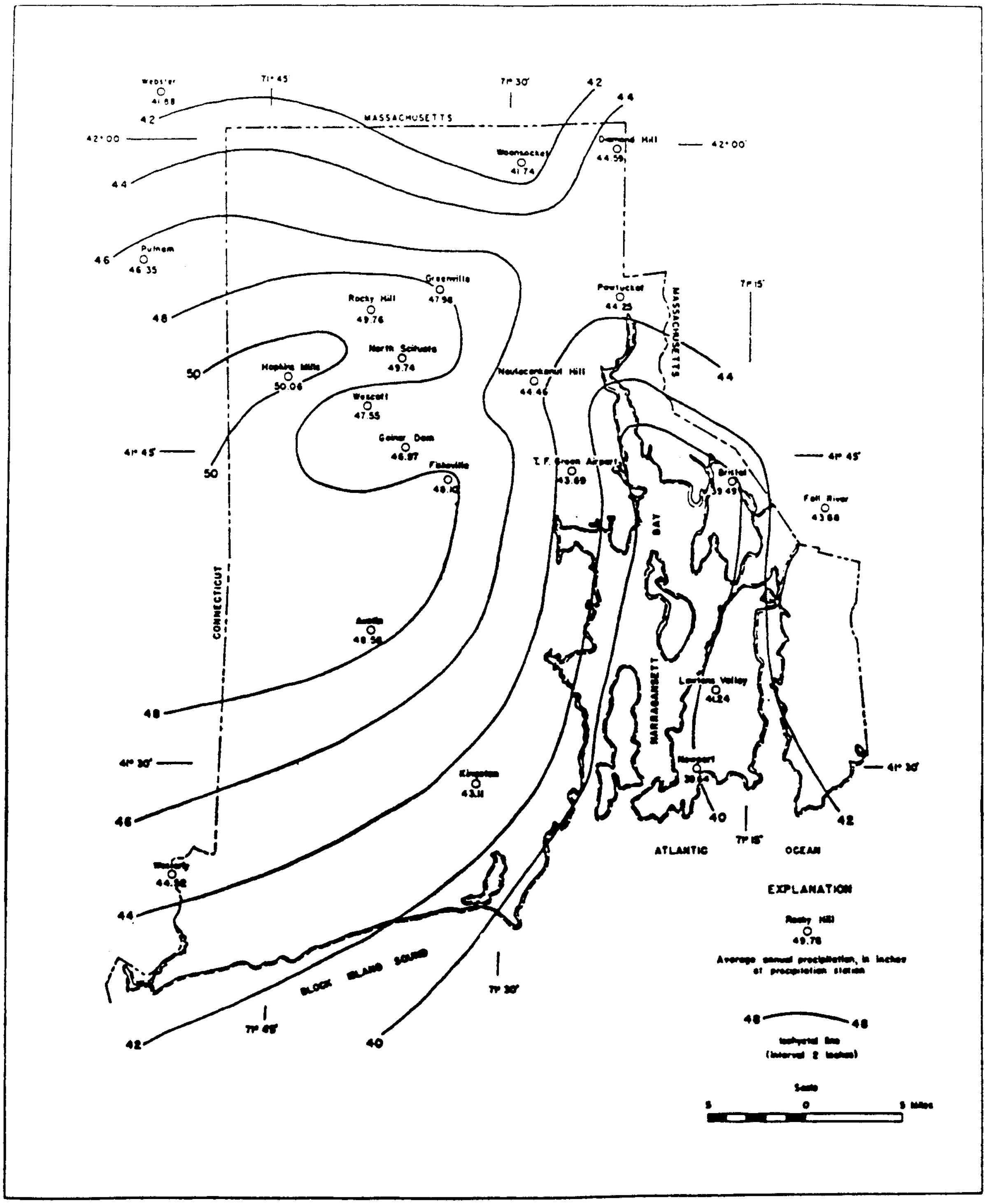
The total contributing drainage area (acres) can be obtained from site plans. C (poilutant concentration)

Choose the appropriate value of C from Table 14.1.

Sample calculations:

A 30 acre undeveloped parcel is to be developed into a residential subdivision with the remaining TO acres converted to a commercial plaza. Assume the commercial landuse area has impervious surfaces

Figure 14.1 Average Annual Precipitation in Rhode Island, 1940-1956.
(Source: USGS, 1961)



covering 85% of the area, while the residential subdivision has 35% impervious surfaces. Also assume the entire 30 acre site has all drainage directed to one outlet (into a coastal pond). This site is located in an area that receives approximately 45 inches of precipitation per year. What is the potential annual loading rate of nitrogen (total-N) to the coastal salt pond from this site, and compare pre- and post-development scenarios.

Pre-development conditions

Undeveloped site: (Eq.3) Rv = 0.05 + 0.009(1) = 0.05 + 0.009(0) = 0.05

(Eq.l) L = [(P)(Pj)(Rv)i(12)](C)(A)(2.72); from Table 14.1, C = *1.355*

L = [(45)(0.9)(0.05)/12](l.355)(30)2.72 = 18.65 lbs total-N

Post-development conditions

Residential: (Eq3) Rv = 0.05 + 0.009(1) = 0.05 + 0.009(35) = 0.365 (Eq.1) L = ftP)(Pj)(Rv)/(l2)](C)(A)(2.72); from Table 14.1, C = 2.030

L = *[(45)(0.9)(0.365)/12](2.030)(20)2.72* = 136.04 lbs total-N/year Commercial: (Eq.3) Rv = 0.05 + 0.009(I) = *0.05* + 0.009(85) = 0.815 (Eq. 1) L = [(P)(Pj)(Rv)/(l2)](C)(A)(2.72); from Table 14.1, C = 2.300

L = *[(45)(0.9)(0.815)112](2.300)(10)2.72* = 172.08 lbs ***total-N/year***

Total annual nitrogen loading from the developed site = 136.04 + 172.08 = 308.12 lbs

Conclusion: Development of the site results in a net increase of 289.47 lbs of nitrogen (308.12- 18.65) into the coastal salt pond.

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APPENDIX A

What is a "stormwater discharge associated with industrial activity"?

The November 16, 1990 regulation established the following definition of "stormwater discharge associated with industrial activity" at 40 Codified Federal Register 122.26(b)(14):

"Stormwater discharge associated with industrial activity" means the discharge from any conveyance which is used for collecting and conveying stormwater and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the National Pollution Discharge Elimination System (NPDES) program under 40 CFR Part 122. For the categories of industries identified in subparagraphs (i) through (x) of this subsection, the term includes, but is not limited to, stormwater discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste materials, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR 401); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials,and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to stormwater. For the categories of industries identified in subparagraph (xi), the term includes only stormwater discharges from all the areas (except access and roads and rall lines) that are listed in the previous sentence where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are <u>exposed to stormwater</u>. For the purposes of this paragraph, material handling activities include the: storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the dralnage from the excluded areas is not mixed with stormwater drained from the above described areas. Industrial facilities (including industrial facilities that are Federally, State, or municipally owned or operated that meet the description of the facilities listed in this paragraph (i)-(xi)) include those facilities designated under the provisions of 122.26(a)(l)(v). The following categories of facilities are considered to be engaging in "industrial activity":

1. Facilities subject to National effluent limitations guidelines for stormwater. [Section 122.26(b)(l4)(i)

2. Manufacturing facilities classified as Standard Industrial Codes (SIC) 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, and 373. These codes include lumber; paper mills; chemical; petroleum; rubber leather tanning and finishing; stone, clay, and concrete; metal; enameled iron and metal sanitary ware; and ship/boat manufacturing facilities. [Section 122.26(b)(1~)]

3. Mining and oil & gas operations classified as SIC codes 10 - 14 including active and

inactive mining and oil and gas operations with contaminated stormwater discharges,except for areas of coal mining operations which have been reclaimed and the performance bond has been released by the appropriate SMCRA authority, or non-coal mining operations which have been released from applicable State and Federal reclamation requirements after December 17, 1990. [Section l22.26(b)(14)(iii)]

4. Hazardous waste treatment, storage, or disposal facilities. [Section l22.26(b)(14)(iv)]

5. Landfills, land application sites, and open dumps that receive industrial wastes. [Section 122. 26(lb)(14)(v)]

6. Recycling facilities classified as SIC codes 5015 and 5093. These codes include metal scrap yards, battery reclaimers, salvage yards, and automobile yards. [Section l22.26(~b)(14)(vi)]

7. Steam electric power generating facilities (including coal handling sites, and on-site and off-site ancillary transformer storage areas). [Section 122.26(b)(l4)(vii)1

8. Transportation facilities classified as SIC codes 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 which have vehicle maintenance shops, material handling facilities, equipment cleaning operations or airport dc-icing operations. These also include railroad, mass transit, school bus, trucking and courier services, postal service, water transportation, and airport facilities. [Section 122.26(b)(14)(viii)]

9. Sewage treatment plants treating domestic sewage, or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of sewage (including land used for the disposal of sludge located within the confines of the facility) with a design flow of 1.0 MGD or more or required to have an approved pretreatment program. This does not include farm lands, domestic gardens, or lands used for the beneficial reuse of sludge which are not physically located in the confines of the facility. [Section 122.26(b)(14)(ix)]

10. Construction activities, including clearing, grading and excavation activities except operations that result in the disturbance of less than S acres total land area which are not part of a larger common plan of development or sale. [Section 122.26(b)(14)(x)]

11. Other specific facilities where materials are exposed to stormwater classified under SIC codes 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37, (except 373), 38, 39, and 4221-25. These codes include food; tobacco; textile; apparel; wood kitchen cabinets; furniture; paperboard containers and boxes; converted paper/paperboard products; printing; drugs; leather; fabricated metal products; industrial and commercial machinery and computer equipment; electronic equipment; transportation equipment; measuring, analyzing, and controlling instruments and photographic, medical, and optical goods, and watches and clocks; and glass manufacturing, and certain warehousing and storage establishments. [Section 122.26(b)(14)(xi)]

APPENDIX B

PS URBAN CATCHMENT MODEL

DATA ENTRY WORKSHEET

Notes:

1) Data inputs denoted with an - are user defined inputs (labels, notes, filenames)
2) Data inputs denoted with a "$" should be available from drainage plan (hydrologic sequence, watershed and device characteristics)
3) Data inputs denoted with "e" should be taken from look up tables provided on the model help screens or from other available sources
4) Data inputs denoted by a number in parentheses *(l)* are selected from available computer disk files.
5) Data inputs denoted by -+- Use default values unless more detailed site—specific information is available.

CASE EDIT FIRST (title, file names, **user reference notes)**

Case Title (Label): ________________*

Case Data File (Filename.cas):

Storm Data File (Filename.stm): __________(1)

Notes (User reference about case): *

Site Schematic Diagram:

CASE EDIT DEVICE **INDEX (define list of** treat.ent **devices for simalation)**

NO.	LABEL*	TYPES	NO.	LAZEL*	TYPE$	NO.	LABEL*	TYPES
2		_	10	_____		18	_____	
3	_____		11	_____		19	_____	
4		_	12	_____		20	_____	
5		_	13		_	21	_____	
6		_	14		_	22	_____	_
7		_	15	_____		23	_____	_
8	_____		16	_____		24	_____	

1—detention pond 2—infiltration basin 3—swale/buffer **4—general**

5—pipe/manhole 6—splitter 7—aquifer

PS URBAN CATCHMENT **MODEL**
DATA ENTRY WORKSHEET

CASE EDIT WATERSHEDS INDEX **(define list of watersheds for simulation; 8 character watershed label,** and downstream discharge **location)**

NO.	LABEL[1]	OUTFLOW DEVICE$	NO.	LABEL[1]	OUTFLOW DEVICES	NO.	LABEL*	OUTFLOW DEVICES
	_		9	_		17	_	
2	_____		10	_____		18	_____	
3	_____		11	_____		19	_____	
4	_____		12	_____		20	_____	
5	_____		13	_____		21	_____	
6	_____		14	_____		22	_____	
7	_____		15	_____	_	23	_____	
B	_____	_	16			24		

CASE EDIT WATERSHEDS **DATA** (specify **watershed specific data)**

Watershed Number (as specified In watershed index): *

Watershed Label (as specified in watershed index): *

Outflow **device number (downstream surface water device sequence):** ___$

Aquifer Device Number (down **gradient movement to aquifer):** ___$

Total Area (acres): ___$

Impervious Fraction (impervious area/total area): __$

Depression Storage (inches): ___€

Sweeping Frequency (times/week, if applicable): S

Pervious Curve Number (based on hydrologic soils group): _____S Scale Factor for Pollutant Load (default value — 1): —+

PS URBAN CATCEXENT MODEL
DATA ENTRY WORKSHEET

CASE EDIT DEVICE **DATA** - DETENTION POND

Device No. (specified in device index): *
Label (specified in device index): ____*
Bottom Elevation (feet; for reference only): ___________$

	Area (acres)	Volume *(ac-fl)*
Pond Bottom		$
Permanent Pool		________$
Flood **Pool**	______	________$

Infiltration Rate (in/hr; flood pool only): ____€

Normal Outlet (specify only one)$:

Flood Pool Drawdovi, Time (hours): ___

Outlet orifice diameter (inches): __

Outlet weir length *(feet):* __

Riser Height (feet): __**Boles (*):** _Role diameter (inches):

Outlet **Device Numbers (dovnstreaa** flov direction):5

Normal Outlet:

Spillway: __

Infiltration:

To direct flow out of system set device number to "0" or to other device number
listed in device index.

PS URBAN CATCEMENT MODEL
DATA ENTRY WORKSHEET

CASE EDIT DEVICE **DATA** - GENERALIZED DEVICE

-Defines elevation, area, discharge table for device with up :o three outlets:
si.tilar input is required for hydrologic models (i.e., TR—2O)

Device No. (specified in device index): _____*
Label (specified in device index): *

			NORMAL	
		INFILTR.	OUTLET	SPILLWAY
OUTFLOW DEVICE NUMBERS				_____$
ELEVATION	AREA		OUTFLOW RATES	
feet$	**acres$**		**cfs$**	

To direct flov out of system set device number to “0” or to other device number listed in device index.

CASE EDIT DEVICE DATA - INFILTRATION BASIN

Device Number (specified in Device index): *
Dev~ce Label (specified in device index): *

~ottom Elevation (feet): ___ $
Bottom Area (acres): ____
Storage Pool Area (acres): ___ $
Storage Pool Volume (acre—ft): ____ $
Void Volume Percent (Z; default – 100): +

Infiltration Rate (inches/hour):

Outflow Device Nunbers:
Overflow: $
Exfiltrate: ___ $

CASE EDIT DEVICE DATA - SVALE/BUFY~ STRIP
Device Number: *
Device Label: *

Bottom Elevation (feet): ___ $
Flow Path Length (feet): ____ $
Flow Path Slope (Z): ____

Bottom Width *(feet):* ____ $
Side Slopes (ft—h/ft—v): ____ $

Maximum Depth (feet): $
Manning's N: 5
Infiltration Rate (in/br): S

Outflow Device Numbers:
Overflow: ______ $

Exfiltrate: ___

To direct flow out of syste. set device number to "0" or to other device number listed in device index.

P8 URBAN CATCHXENT MODEL
DATA ENTRY WORKSaRET

CASE EDIT DEVICE DATA - PIPE/MANHOLE
Device Number: *
Device Laoel: *

Tine of Concentration (hrs; default. 0): +

Outflow Device Number: $

CASE EDIT DEVICE DATA - FLOW SPLITTER
Device Number: *
Device Label: *

Outflow to Device: _____$ If Surface Elev. < Feet Otherwise, outflow to alternative device:

Time of Concentration (hrs; default – 0): +

CASE EDIT DEVICE DATA - AQUIFER

Device Number: _-_·
Device Label: *

Outflow Device Number: ___$

Time of Concentration (hrs; default - 0): +

To direct flow out of syste. set device number to “0” or to other device number listed in device index.

APPENDIX C

DATE: July, 1987

AuThOR: Thomas A. Schueler
Department of' Environmental Programs
Metropolitan Washington counci of Governments
Water Resources Planning Board

AGENCY: The 'letropol tan Washington council of Governments is the regional organization of the Washington. DC, area's major local governments and their governing officials. COG works towards sollutons to such regional problems as energy shortages, traffic congestion, na'deqiiate housing, air and water p01 lution. The Washington Metropol tan Water Resources Planning Board Serves as the areawide wastewater management agency for the Washington area. The Board is involved with regional p0l icy issues related to provision of adequate wastewater treatment, sludge disposal, nonpoint source pollution control, and municipal water supplies.

REPORT
ABSTRACT: Nlanua I provides deta , led guidance for eng nners and s i tep I anners on how to plan and desgn urban best management practices (BMPs~ to "emove pcI ILitants and protect stream habitat. Describes water quality and habi tat imeacts in streams tnat result from uncontrolled watersned development. Conta,ns a simple method for estimating pollutant export from development sites. Presents a seres of tools to ass! st toe Si tC designer in select ng the best EMP option for a Si te. Provides detailed design guidance on seven major urban BMP practices in use in the Washington Metropolitan Area:
extended detention ponds, wet ponds, infiltration basins and t-enches, porous pavement, water qua I i ty n lets and vegetative practices. Each BMP is reviewed from the standpoint of stormwater management benefi ts, pollutant removal, physical feasibility, costs, maintenance reqLieeents, and impacts to the envi ronlment and adjacent comrnuni ties. A Ii St or recommended design standards that enhance BNIP performance is also presented.
275 pp., 'with 2 Appendices, Glossary and Reference List. 66 Figures, 29 Tables, and 11 Examples,

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ABSTRACT

TITLE:	A Current Assessment (if Urban Dest .Management Practices: Techniques for Reducing Nonpoin Surce Polluhon in the Coastal Zone.
DATE:	March 1992
A DING R:	Anacost ia Ees tn rat jun Team Ok par tni en t 01 F :i?i rerun en to I Progra ni Metropolitan V,',isli.ington Council of Governments
ACDOCY:	The Me tropul j Li n 'Oi'a shj ngto n Counci of *Go* vernn', en ts is th o regional planning orga ni/a tio n of I he Washington, D.C. area's ma gir local governments and their governing o fft orals. CDG works ti i sva rd solutions to such regional problems such as energy shortages, rratiic congestion, inadequate housing, air and water pollution. The US Environmental Protection Agency works toward the reduction and elimination of na donal pollution problems. It develops guidelines for the i no plenienta torn of onviri iii' mental legislation, enforces national pollu don control programs, offers technical assistance to state and local programs, and provides guidance in determining future nahonal pollution control priorities.
RE PORT A DETRACT:	Sum man/es the capabilities and limitations of stnoctural best noanagement practices in current use icr the control of the quality of urban runoff. Addresses issues of particular concern to the coa stal zone Observations are derived from multiple field studies. Includes assessments ot extended detennon ponds, wet ponds, stormwater wetlands, multiple pond systems, infiltratIon trenches, infiltration basins.porous pavoment,sand filters, grassed swaies,vegetated filtenstrlpsand waterqualitvinlots. For each practice, the report discusses pollutant removal capability, longevity, environmental impacts, construction and maintenance costs., feasibility in different development contexts, and adaptability to different geographic settings, particularly coastal, The report also suggests improvements under development for each practice, intended to correct notable design flaws ur increase overall storm water management capability.
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